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Potato (*Solanum tuberosum*) aeroponics for quality seed production in north eastern Himalayan region of India

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ABSTRACT

The study was conducted at Central Potato Research Station, Shillong during 2013 and 2014 to evaluate the performance of three potato (*Solanum tuberosum* L.) varieties, viz. Kufri Megha, Kufri Himalini and Kufri Himsona in an aeroponics system installed under net cum polyhouse. All the varieties exhibited more than 90% survival with root initiation within 4-5 days of transplanting. Kufri Megha started tuber initiation within a month in both the years. Tuber initiation was late in Kufri Himalini in 2014 (60 days) as compared to 2013 (39 days). Kufri Himsona exhibited delayed tuber initiation at 69 to 75 days after transplanting in both the years. The first picking was done within 40 and 80 days after transplanting in Kufri Megha and Kufri Himsona, respectively, in both the years. First picking in Kufri Himalini was delayed by 15 days in 2014 as compared to 50 days after transplanting in 2013 due to delayed tuber initiation. The crop duration of Kufri Megha was 110 and 134 days in 2013 and 2014, respectively, allowing for 8 to 9 pickings that yielded 108 to 118 g tubers/plant (38 to 42 tubers/plant) with mean mini-tuber weight of 2.91 to 2.96 g. The number of pickings reduced significantly from 11 to 5 in Kufri Himalini and 7 to 4 in Kufri Himsona from 2013 to 2014. In Kufri Himalini, delay in tuber initiation and reduction in crop duration was observed in 2014. There was a significant reduction in per plant yield in both Kufri Himalini (162 g to 102 g) and Kufri Himsona (138 g to 39.25 g) accompanied by reduction in number of tubers/plant (38 to 27 tubers in Kufri Himalini and 29 to 11 tubers in Kufri Himsona). The mean mini-tuber weight also reduced from 4.32g to 3.87g in Kufri Himalini and 5.03g to 4.13g in Kufri Himsona.

Key words: Aeroponics, Mini-tubers, NEH region, Potato

Potato (*Solanum tubesosum* L.) is an important crop of the region contributing nearly 10% of the country's total potato area. The area under potato, as a percentage of the net-cropped area, is about four times of the national level in the region (Kumar *et al*. 2008). However, average potato yield in all NE states has been low as compared to national average of 22.76 tonnes/ha (NHB 2013). The most important factors contributing towards low yield in the region includes non-availability of quality seeds and other inputs and prevalence of biotic and abiotic stresses during crop season (Srivastava *et al*. 2012).The entire NE region is unsuitable for producing potato breeder seed through conventional method due to high aphid population during crop season, high rate of degeneration due to viruses and soil borne pathogens like bacterial wilt. Non-conventional approaches of micro-propagation of nodal cuttings of potato and further multiplication of mini-tubers in net houses are being followed for production of high quality seeds in the region. The main constraint in this system is the low productivity (6-8 tubers/plant) and incidence of soil borne diseases (Nugaliyadde *et al*. 2005). In India, this system usually yields 6-10 mini-tubers/plant in hills (Sharma *et al*. 2010) and 7-12 mini-tubers/plant in plains (Kumar *et al*. 2011, 2012) depending upon the genotype. One plausible solution to this problem is to adopt a soil-less seed production system. Aeroponics is primarily a process of growing plants in air, or misty environment by time bound spray application of all the required nutrients without the use of soil or an aggregate media (Otazu, 2010). Being a new technology, it needs to be adapted to the local conditions, viz. the varieties grown in the region, designing the crop geometry, plant protection schedule etc.In the present study, an attempt has been made to evaluate the relative performance of Kufri Megha, Kufri Himalini and Kufri Himsona for mini-tuber production in the NE region under an aeroponics system.

MATERIALS AND METHODS

The study was conducted under net cum polyhouse

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at Central Potato Research Station, Shillong (1800 m AMSL, 25.54°N, 91.85°E) during 2013 and 2014. Three varieties recommended for cultivation in the north eastern region and representing distinct groups were used. Among these, Kufri Megha, released in 1989 exhibit high late blight resistance while recently released Kufri Himalini exhibits moderate level of late blight resistance. Kufri Himsona exhibits moderate level of late blight resistance and is suitable for processing.

The aeroponics system was based on the structure developed at CPRI Campus Modipuram (Singh *et al*. 2010) with some improvements to suit the local needs of the NEH region. Potato micro-plants of Kufri Megha, Kufri Himalini and Kufri Himsona were planted in pro trays in coco-peat media and hardened for about 10 days and then transplanted on the styrofoam sheet panels, each containing 28 plants at spacing of 14 cm × 16 cm. Planting was done by 15 March in 2013 and 15 April in 2014. The microplants were supplied with nutrient solution containing all the essential macro and micro-nutrients by spraying in fine mist in the root zone periodically and solution was renewed in every two weeks. Mini-tubers with diameters larger than 20-25 mm (≥3g) were harvested by picking at 10 days interval.

The nutrient solution containing all the essential macro and micro-nutrients were supplied to the root zone by periodic spraying in fine mist to keep it saturated. The pH of the nutrient solution was maintained between 5.5 to 6.5 with electrical conductance (EC) ranging between 2.0 to 2.5 mS/cm. The nutrient solution was renewed in every two or three weeks to replenish the nutrients and maintain the correct pH.

The experiment was laid in a randomized block design with 7 replications, each panel constituting a replication. Observations were recorded on plant height (cm), root length (cm), number of leaves/plant, days to root initiation, days to tuberization, days to senescence, number of harvests/pickings, number of mini-tubers/plant, yield of mini-tubers/plant (g) and average weight of mini-tuber (g). Days to tuberization were recorded as the number of days when more than 65% of plants starts tuber formation. Days to senescence were recorded as days when more than 90% of foliage turns yellow. The data were subjected to analysis of variance (ANOVA) for testing the significance of variation for different characters as described by Gomez and Gomez (1984). Mean values were calculated and compared using t-test at 5% level of significance.

RESULTS AND DISCUSSION

The effect of varieties as well as years was significant for all the characters studied (Table 1). This indicated that even under aeroponic system of cultivation where there is no dearth of nutrients and practically no other limiting factors, the genetic potential of the variety regulates its growth and mini-tuber production potential. The significant difference in performance of these varieties over years was expected as the aeroponics structure is not fully climate control and the differences in the weather parameters prevailing during both the years have played their role in variable expression of growth and yield parameters. The significance of variety × year interaction reveals that the environment is not uniformly affecting all the varieties. Thus some varieties are better able to cope with the differences over year than others resulting in differential performance of the varieties.

Initial growth

Initial survival and growth of potato micro-plants is crucial in attaining successful growth under aeroponic cultivation. All the three varieties showed excellent survival after transplanting with more than 90% survival. In an aeroponic system, the general principle is to allow development of a specific volume of root and shoot system and then tuber initiation. Ideally tuberization in potato micro-plant should begin after 30 to 45 days when plants have grown substantially to support rapid tuber development. Any deviation from this may affect tuber yield.

In the present study, root initiation began within 4-5 days in all the varieties. During first three weeks, all the varieties showed sluggish stem growth ranging from 8.1 cm in Kufri Megha to 12.8 cm in Kufri Himalini (Fig 1). Root growth was comparatively faster during this period with root length ranging from 25.5 cm in Kufri Himsona to 35.2 cm in Kufri Himalini. The number of leaves/plant also showed slow increment during first three weeks. During next three weeks the root and shoot system showed rapid

Table 1 Yield performance of potato micro-plants of three varieties under aeroponics system

Varieties/Year	Days to tuberization		Days to senescence		No of Mini-tubers/plant		Yield of mini-tubers/plant		Average mini-tuber weight (g)	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Kufri Megha	32.67	30.00	109.29	134.00	42.68	38.11	118.54	108.94	2.91	2.96
Kufri Himalini	39.10	60.00	147.71	127.00	38.12	27.04	161.80	102.16	4.32	3.87
Kufri Himsona	69.00	75.00	137.29	136.00	29.36	10.56	138.38	39.25	5.03	4.13
CD (P=0.05)										
Variety	1.11		2.72		0.74		2.37		0.08	
Year	1.28		3.14		0.85		2.73		0.09	
Variety × Year	2.21		5.43		1.48		4.74		0.16	

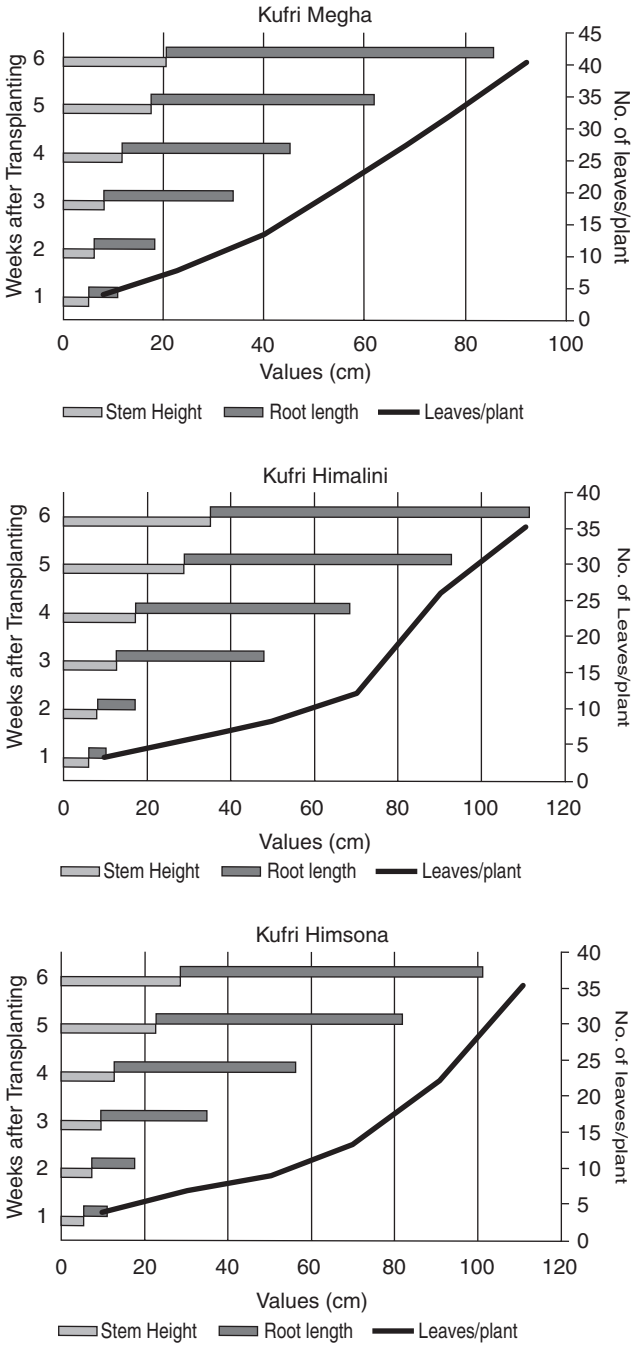

Fig 1 Growth of potato micro-plants of three varieties under aeroponics system during initial developmental phase

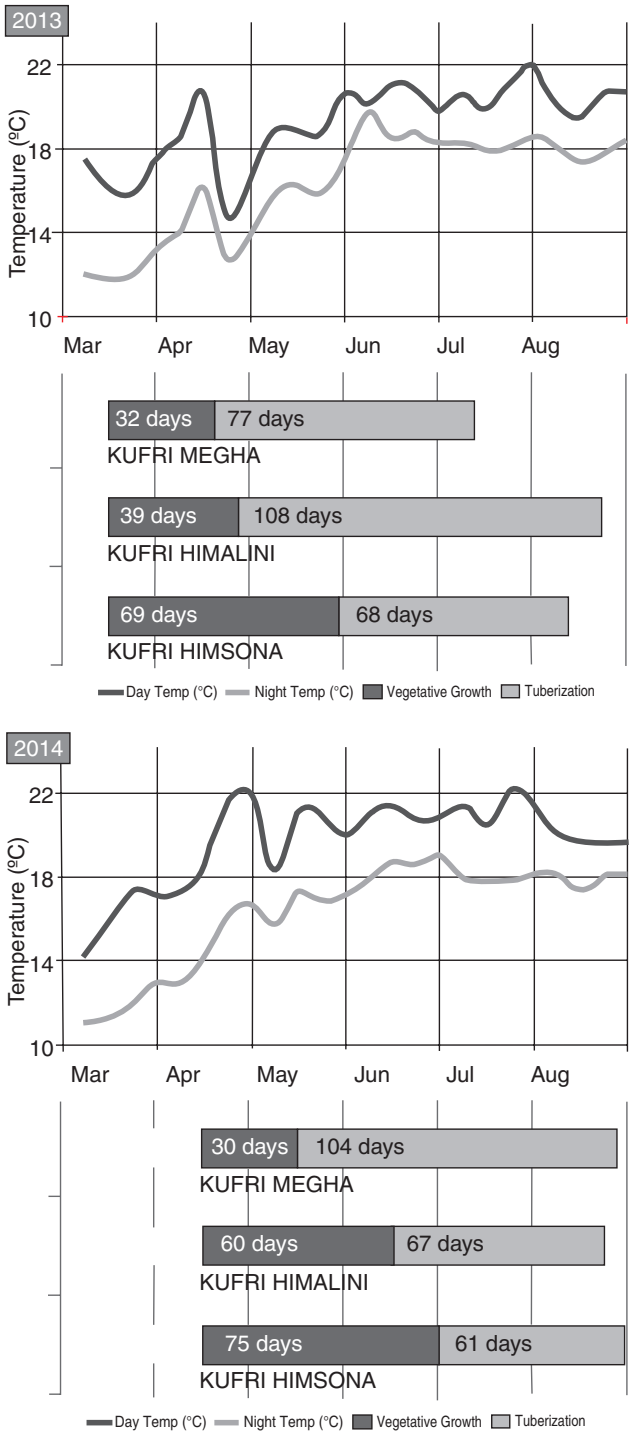

Fig 2 Vegetative and Tuberization period in potato varieties in relation to temperature profile

development in all the varieties. During initial phase, the root volume was less due to which the nutrient uptake was relatively slower although plenty of nutrients were supplied through misting. Once the roots attained critical volume after three weeks, it was able to uptake more amount of nutrients leading to rapid growth of the plant.

Tuber initiation

Kufri Megha started tuber initiation within a month in both the years. Tuber initiation was late in Kufri Himalini in 2014 (60 DAP) as compared to 2013 (39 DAP) (Fig 2). Kufri Himsona exhibited delayed tuber initiation at 69 to 75 DAP in both the years. First picking was done within 40 and 80 DAP in Kufri Megha and Kufri Himsona, respectively, in both the years. First picking in Kufri Himalini was delayed by 15 days in 2014 as compared to 50 DAP in 2013 due to delayed tuber initiation.

Crop duration

The crop duration of the varieties in the aeroponics

varied from those under field condition. Kufri Megha reported as late maturing variety (120-145 days) while Kufri Himalini and Kufri Himsona are medium maturing varieties (110-120 days) under field conditions (Luthra *et al*. 2008).Under aeroponics cultivation, the crop duration of Kufri Megha varied from 109 to 134 days, respectively in 2013 and 2014. This increase in crop duration is mainly due to increase in tuberization period in 2014. Kufri Himalini exhibited crop senescence in 147 and 127 days, respectively in 2013 and 2014. This reduction by 20 days was followed with increase in vegetative growth period and decrease in tuberization period in 2014. Although overall crop duration remained similar in Kufri Himsona (136-137 days), the vegetative period was more in 2013. This may be due to higher night temperature (> 18^{o}C) during crop growth period in 2014 which not only delayed tuber initiation but affected tuberization period (Fig 2). Differences in vegetative cycle of potato genotypes grown under aeroponics from those grown under field condition had been observed by earlier workers and attributed to high nitrogen and oxygen availability in the nutrient solution (Ritter *et al*., 2001, Masengesho *et al*. 2012).

Mini-tuber production

In Kufri Megha, the mini-tuber yield/plant varied from 108 to 118 g in 2013 and 2014, respectively. It produced 38 to 42 mini-tubers/plant during 8 to 9 pickings in 2013 and 2014, respectively. The average mini-tuber weight varied between 2.91 to 2.96 g in 2013 and 2014, respectively. The sequential harvesting of mini-tubers in aeroponic system increases the yield especially tuber number as the removal of the dominant large tubers allows initiation of new tubers as well as the development of existing ones (Ritter *et al*. 2001, Mbiyu *et al*. 2012).The number of pickings reduced significantly from 11 to 5 in Kufri Himalini and 7 to 4 in Kufri Himsona from 2013 to 2014. Yield/plant was reduced in both Kufri Himalini (162 g to 102 g) and Kufri Himsona (138 g to 39.25 g) along with reduction in number of mini-tubers/plant (38 to 27 tubers in Kufri Himalini and 29 to 11 tubers in Kufri Himsona) in 2014. The mean mini-tuber weight also reduced from 4.32g to 3.87g in Kufri Himalini and 5.03g to 4.13g in Kufri Himsona in 2014.The performance of Kufri Himalini and Kufri Himsona were not uniform across the years probably due to higher night temperature (> 18^{o}C) during crop growth period in 2014 which not only delayed tuber initiation but also reduced the crop duration in Kufri Himalini by 20 days in 2014. The variable performance of varieties over years indicates the need for developing genotype specific growth schedulefor obtaining optimum yield from the system.

Although all the three varieties were able to produce mini-tubers under aeroponics culture in the NEH region, the performance was far from satisfactory in Kufri Himalini and Kufri Himsona in 2014. This necessitates the need to establish standard planting dates and growing conditions in the aeroponics system based on the existing environmental condition of the NEH region. It is much safer option to match the growing period under aeroponics with the general growing period of the crop in the field by adjusting the date of planting to February.

From the present study, it can be concluded that aeroponics system can be successfully utilised for augmenting the production of tissue culture based disease free quality seed potato in the NE regions all the three varieties were able to produce mini-tubers. Sequential harvesting of mini-tubers allows selection of desired size for the mini-tubers. However, non-uniform performance of varieties over years calls for cautious optimism in widespread use of technology. The crop growth and crop protection schedule should be optimised based on cultivars and crop growing condition for obtaining sustainable higher yield from the aeroponics system. Further multiplication of aeroponically harvested tubers also need specific planting strategies as tubers of different harvest dates may vary in their dormancy status during next planting. The mini-tubers harvested from the aeroponics system also need systematic storage which includes initial greening at higher relative humidity followed by storage in cold stores.

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