



Standardization of agro-techniques for aeroponic potato (*Solanum tuberosum*) minitubers under generation-0

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Received: 25 September 2019; Accepted: 21 November 2019

ABSTRACT

Since, very less information is available regarding the agro-techniques of hi-tech seed potato minitubers production, therefore an experiment was conducted to evaluate planting geometry and different doses of nitrogen for multiplication of aeroponic minitubers of potato (*Solanum tuberosum* L.) under net house conditions of north-central plains of India. 30 cm × 15 cm (97.44) plant geometry and 150 kg N/ha (95.81) and 180 kg N/ha (96.98) N dose recorded significantly higher emergence %. Linear increase in plant height was recorded with 120, 150 and 180 kg N/ha dose over 75 kg N/ha (44.1 cm). Planting geometry 45 cm × 10 cm (34.71) and N dose 150 kg N (35.71) recorded significantly lowest per cent of <3 g minituber by number. Planting geometry 45 cm × 10 cm (1722 thousand/ha) followed by 30 cm × 10 cm (1587 thousand/ha) recorded significantly highest total tuber number over 30 cm × 15 cm (1209 thousand/ha). Among N dose, 120 kg N (1560 thousand/ha) and 180 kg N/ha (1506 thousand/ha) dose recorded significantly higher total tuber number over 150 kg N/ha dose. Among interaction 45 cm × 10 cm with 120 kg N/ha dose recorded significantly highest total tuber number (1823 thousand/ha) over other combinations. For weight of tubers, 45 cm × 10 cm planting density with 150 kg N/ha reported highest tuber weight (27.62 t/ha). Hence, for the aeroponic seed multiplication of the variety Kufri Lauvkar, planting geometry of 45 cm × 10 cm with plant population of 222222 plants/ha and N, P₂O₅ and K₂O ratio of 150:60:100 kg/ha should be adopted for getting higher tuber number and weight/ha.

Key words: Aeroponic minituber, Nitrogen doses, Planting geometry, Potato seed production

Aeroponics is a process of growing plants in air, or misty environment by time bound spray application of required nutrients without the use of soil or an aggregate media (Otazu 2010). It is a cost-effective and more efficient method of pre-basic quality seed production (Ritter *et al.* 2001) and its optimization is important for sustainable production of potato (*Solanum tuberosum* L.) (Rykaczewska 2016). Considering the potential benefits, viz. rapid production, healthy and clean material and eco-friendly nature, aeroponic system has a potential of revolutionizing potato seed production (Buckseth and Singh 2018, Mateus-Rodriguez *et al.* 2013). One of the main concerns of potato aeroponic minituber is the lack of information for its further multiplication. Planting density is critical to improve tuber number during each planting cycle (Santos and Rodriguez 2008). An ideal combination of plant population, row width, and in-row seed spacing for a particular variety are the major factors for optimizing tuber size and increasing grower's revenue (Kaur *et al.* 2019).

Nitrogen is necessary for potato from emergence to maturity and its demand increases rapidly after emergence

and falls when 75% of the plant growth is completed. Any delay in nitrogen particularly during early active phase of growth, results in a set back to the crop (Sinha 2007). Higher rate of nitrogen provided better growth, development and translocation of photosynthates from source to sink (tuber) (Patel and Patel 2001). Growth and yield parameters gradually increased with the gradual increase of nitrogen level and plant spacing (Negero 2017 and Sriom *et al.* 2017). Presently 30 cm × 10 cm planting geometry and 150:60:100 N, P₂O₅ and K₂O kg/ha is being practiced for multiplication of aeroponic minitubers under G-0, which was standardized for multiplication of *in-vitro* plantlets and microtubers (1–3 g in weight) of potato (Muthuraj and Ravichandran 2016). Major consideration in any seed programme under G-0 should be production of acceptable plantable size of tubers for further field multiplication in G-1, which can be achieved with proper planting geometry and N, P₂O₅ and K₂O dose, hence present experiment was conducted to standardize agro-techniques for aeroponically produced minitubers under G-0 protected cultivation.

MATERIALS AND METHODS

An experiment was conducted in the net house of ICAR-Central Potato Research Station, Gwalior (26° N and 78° E, altitude 207 m amsl) with cultivar Kufri Lauvkar

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during 2017–18 and 2018–19. Aeroponic minitubers (4–5 g) were allowed to sprout under diffused light and planted in the 2nd week of November. Seed bed was prepared with one inch thick layer of well decomposed farm yard manure and sand in the ratio of 1:1 on the top of the bed under insect-proof net house. Well sprouted aeroponic minitubers were planted with three planting geometries, viz. 30 cm × 10 cm, 30 cm × 15 cm and 45 cm × 10 cm in ridge and furrow planting with 3 rows (2 m) which maintained the planting density of 333333, 222222 and 222222 with four nitrogen doses kg/ha (N) along with phosphorous (P₂O₅) and potassium (K₂O), viz. 75:30:50, 120:60:100, 150:60:100 and 180:60:100 in factorial RBD with three replications. Full doses of P through single super phosphate, K through muriate of potash and half dose of N through ammonium sulphate were applied at the time of planting. Remaining half dose of N was applied through urea. Standard seed production practices were followed for the management of the crop, using overhead sprinkler system for irrigation. The morphological observations on stem per plant, plant height and number of leaves were recorded at 75 days after planting (DAP). The crop was terminated at 90 days by cutting haulms and harvested after allowing skin curing for 15 days. Yield, total number of tubers, tuber grades, viz. undersize (<3 g) and >3 g were recorded. Data were pooled and analysed statistically and means were separated according to the least significant differences (LSD) at 0.05 level of probability

RESULTS AND DISCUSSION

Emergence and growth parameters

Emergence (%): 30 cm × 15 cm plant geometry recorded significantly higher emergence % (97.44) over 30 cm × 10 cm (94.79) and 45 cm × 10 cm (93.82) at 30 DAP. Higher emergence in the 30 cm × 15 cm plant geometry may be due to more intra-row distance (15 cm) among the minitubers and comparatively low germination at higher plantlet geometry which might be due to increased competition for space and

nutrients. Singh *et al.* (2019) reported decreasing trend in plant emergence with increasing plant density at 35 DAP. Similar results were also reported by Sharma *et al.* (2014). Increasing trend was recorded with increase in N dose and significantly higher emergence (%) was reported in 150 kg N/ha (95.81) and 180 kg N/ha (96.98) over 75 kg N/ha (93.76) (Table 1).

Plant height (cm): Among planting geometry, plant height was non-significantly higher in 30 cm × 10 cm (50.9 cm) planting geometry than other two plant geometries (Table 1). For N dose, significant increase in plant height was reported in 120, 150 and 180 kg N/ha dose over 75 kg N/ha (44.1cm) (Table 1). Plant height increased linearly with increase in fertility level (Nizamuddin *et al.* 2003 Sinha, 2007 and Kumar *et al.* 2017). Increase in plant height might be due to the fact that higher nitrogen stimulated the assimilation of carbohydrates and protein, which in turn enhanced cell division, resulted in enhanced vegetative growth of the plant (Meyer and Anderson 1970).

Stems per plant: In the present study 30 cm × 10 cm planting geometry recorded non-significantly lowest (1.7) stems/plant over other two planting densities (Table 1). Stem number/plant was found non-significant among nitrogen dose but highest was recorded in 150 kg N/ha (1.9). Sinha (2007) reported highest number of shoots per plant at nitrogen level 150 kg/ha at 30, 45, 60 and 75 DAP.

Compound leaves per plant: Maximum leaves/plant was recorded in 30 cm × 15 cm planting geometry which was at par with two planting geometries. Non-significant but increasing trend was reported with increase in N dose for number of leaves/plant (Table 1). Number of stems and compound leaves per plant showed a gradual and significant decrease with the increasing plant density (Singh *et al.* 2019, Sharma and Kumar 2014) but were not affected by the varying levels of nitrogen (Sharma and Kumar 2014). Successive increase in nitrogen levels produced significantly more number of leaves per plant affecting the rate and extent of protein synthesis and thereby increased the number of leaves per plant (Kumar *et al.* 2007 and Sriom *et al.* 2017).

Table 1 Growth parameters of potato as affected by the varying plant geometry and N dose

Planting geometry/ N dose	Emergence (%)	Plant height (cm)	Number of shoots/ plant	No. of leaves/ plant	Mean tuber weight (g)	Per cent of small tuber (<3g) by number	Per cent of small tuber (<3g) by weight
30 cm × 10 cm	94.79	50.9	1.7	20.9	13.8	44.28	9.02
30 cm × 15 cm	97.44	49.3	1.9	21.8	15.5	38.60	5.87
45 cm × 10 cm	93.82	49.6	1.8	19.8	20.3	35.71	5.16
CD (P=0.05)	1.622	NS	NS	NS	2.62	0.787	0.334
75 kg N/ha	93.76	44.1	1.8	19.8	16.2	44.51	6.67
120 kg N/ha	94.84	51.7	1.8	20.4	17.0	41.16	6.76
150 kg N/ha	95.81	50.1	1.9	21.1	14.6	35.87	6.45
180 kg N/ha	96.98	53.9	1.7	22.0	18.4	36.57	6.84
CD (P=0.05)	1.873	5.58	NS	NS	NS	0.909	NS
Interaction	NS	NS	NS	NS	NS	1.574	0.668

Yield of undersize tuber per ha (<3g): There is trend of formation of undersize tubers when microtuber and microplants and aeroponic minituber are multiplied under G-0 (Kaur *et al.* 2019, Sadawarti *et al.* 2017 and Sadawarti *et al.* 2018). Quantification of these tubers is of utmost important for seed production programme. Closer spacing of 30 cm × 10 cm (703000/ha) and 45 cm × 10 cm (615000/ha) recorded significantly higher <3g minituber (Table 2). Similar trend was reported for weight of tuber (t/ha). Higher planting density produced many small minitubers whereas in lower planting density there were fewer and larger minitubers (Santos and Rodriguez 2008 and Srivastava *et al.* 2016). Among different N dose, N75 (665000/ha) and N120 (647000/ha) recorded significantly highest <3g minituber number. For weight also, lower weight 1.22 and 1.30 t/ha in 75 and 120 N kg/ha was recorded than higher N dose. This might be due to more number of tiny tubers produced in lower dose of N. Interaction were significant for tuber number and weight (Table 2) and highest yield by number was recorded in 30 cm × 10 cm with 75N (783000/ha) and by weight was recorded in 30 cm × 10 cm with 180 N kg/ha (1.80 t/ha). Highest yield (weight) of small tuber size was observed for the treatment combination of 10 cm intra row spacing with 150 kg N ha under Ethiopian conditions (Negro 2017).

Per cent undersize tuber: Highest per cent <3g minituber by number was recorded in 30 cm × 10 cm (44.28) and 30 cm × 15 cm (38.60) planting geometry (Table 1). Increased plant density resulted in a significant reduction in the proportionate yield of oversize tubers (Singh *et al.* 2019 and Kaur *et al.* 2019). Comparatively higher proportions of large sized mini-tubers were obtained at low plant density and *vice-versa* due to the increasing competition between for space and nutrients at high plant density (Sharma *et al.* 2014). Among N dose 75 kg N/ha (44.51) and 120 kg N/ha (41.16) recorded significantly higher per cent <3g minitubers over 150 kg N/ha (35.87) and 180 kg N/ha (36.57) (Table 1). Kumar *et al.* (2017) reported decrease in small size tubers with increasing dose of N.

Mean tuber weight: Increasing trend was recorded in mean tuber weight (g) with lower planting geometry and significantly higher was recorded in 45 cm × 10 cm (20.3 g) followed by 30 cm × 15 cm (15.5g) planting geometry. Similar finding were reported by Kumar *et al.* (2012) where higher mean weight of minitubers (progeny tubers) was recorded at wider inter and intra-row spacing's. Higher mean tuber weight in 45 cm × 10 cm and 30 cm × 15 cm planting geometry might be due to wider ridge and spacing respectively, which provided more space for bulking and less intra-specific competition. Non-significant but increasing trend was reported among N dose except 150 N. Maximum average tuber weight was observed for treatment combinations of 30 cm spacing and 150 kg N/ha (Negro 2017).

Total yield per ha

Number of tuber (thousand per ha): Tuber number

Table 2 Yield parameters of potato as affected by the varying plant geometry and N dose (kg/ha) at harvest

Planting geometry/N dose	Yield of under size tuber (<3g)										Total yield per ha										
	by number (000/ha)					by weight (t/ha)					by number (000/ha)			by weight (t/ha)							
	75 kg/ha	120 kg/ha	150 kg/ha	180 kg/ha	Mean	75 kg/ha	120 kg/ha	150 kg/ha	180 kg/ha	Mean	75 kg/ha	120 kg/ha	150 kg/ha	180 kg/ha	Mean						
30 cm × 10 cm	783	846	580	604	703	1.66	1.57	1.72	1.80	1.69	1534	1681	1487	1643	1587	16.56	16.24	21.24	21.79	18.96	
30 cm × 15 cm	526	448	457	437	467	0.89	0.89	1.21	1.37	1.09	1233	1185	1242	1177	1209	16.50	18.02	18.47	20.60	18.40	
45 cm × 10 cm	685	645	524	608	615	1.11	1.44	1.29	1.54	1.35	1719	1823	1646	1698	1722	24.05	25.33	27.62	27.42	26.11	
Mean	665	647	520	550		1.22	1.30	1.41	1.57		1495	1563	1458	1506		19.04	19.86	22.44	23.27		
CD ($P=0.05$)																					
Planting geometry	26.5					0.08					47.1					1.060					
N dose	30.6					0.09					54.4					1.223					
Interaction	53.1					0.16					94.3					NS					

determines the multiplication rates and is crucial for seed potato production. However, the size of the tubers is also important as seed size tubers are more prolific and economically more adaptive (Kaur *et al.* 2019). The yield is indicative of different spacing and fertilizer combination. Planting geometry 45 cm × 10 cm (1722 thousand/ha) followed by 30 cm × 10 cm (1587 thousand/ha) recorded significantly highest total tuber number (Table 2). Whereas higher total number of tuber is due to higher <3g tubers (Table 2). Increased in number of tubers per unit area might be due to more number of plants or stems per unit area in 30 cm × 10 cm plant geometry which is directly related to stem number (Zamil *et al.* 2010, Sharma and Kumar 2014 and Mohamed *et al.* 2018) and in 45 cm × 15 cm might be due to more inter row spacing resulted in better development of plants.

Among N dose 120 kg N/ha (1560 thousand/ha) and 180 kg N/ha (1506 thousand/ha) recorded significantly higher total tuber number. Increased dose of nitrogen up to 120 kg N/ha resulted in a significant increase in the number of tubers and with further increase tuber number did not affect significantly (Sharma and Kumar 2014). Among interaction 45 cm × 10 cm with 120 kg N/ha dose recorded significantly highest total tuber number (1823 thousand/ha). The highest number of tuber/plant (10.46) was reported at the closest spacing of 10 cm with 150 kg N/ha (Negro 2017). In the present study non-responsiveness of further higher doses of nitrogen (180 kg/ha) might be due to limited capacity of the genotype to utilize the greater amounts of nitrogen. This is supported by findings of Sharma and Kumar 2014.

Weight of tuber (tonnes per ha): 45 cm × 10 cm planting geometry recorded significantly higher tuber weight (26.11 t/ha) over other planting geometries. Increasing trend was recorded with increase in N dose and significantly higher tuber weight was reported in 180 kg N/ha (23.27 t/ha) followed by 150 kg N/ha (22.44) (Table 2). Highest total tuber number and weight was reported in 110 kg N/ha under Ethiopian conditions (Shunka *et al.* 2017). Eleiwa *et al.* (2012) reported increased yield with increasing NPK and highest was attained at (120:80:100) rates. Sinha (2007) reported the highest (265.74 q/ha) yield with 300 kg N/ha. Among interaction, 45 cm × 10 cm planting geometry with 150 kgN/ha recorded highest tuber weight (27.62 t/ha). Application of optimum dose of 150, 50 and 75 kg N, P₂O₅ and K₂O /ha was found to be superior in terms of yield and profitability (Kumar *et al.* 2017). Irrespective of plant geometry, increasing doses of nitrogen (up to 180 kg/ha) also resulted in increase in the total yield. Increasing nitrogen levels up to 200 kg N/ha increased the tuber yield (Sirom *et al.* 2017). In the present study almost similar total tuber yields at two plant geometries (30 cm × 10 cm and 30 cm × 15 cm) in spite of significant differences in number of tubers might be due to higher small size of the tubers (<3g) obtained in 30 cm × 10 cm and more plantable (>3g) tubers in 30 cm × 15 cm. A reduction in oversize tubers and an increased in the number of undersize tubers with increased in plant density was also reported by Sharma

and Kumar (2014).

From the results, it can be concluded that for aeroponic seed multiplication under G-0 of potato variety Kufri Lauvkar, planting geometry of 45 cm × 10 cm (222222 plants/ha) and N : P₂O₅ : K₂O dose of 150:60:100 kg/ha should be adopted for getting higher plantable tuber number and weight/ha for multiplication in Generation- 1.

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