Plant Archives Vol. 26, Supplement 1, 2026 pp. 1427-1432 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.189

TABLE SUGAR AS A COST-EFFECTIVE ALTERNATIVE TO SUCROSE FOR *IN VITRO* POTATO MICROTUBER PRODUCTION

Budensha B.[1]*, Kavita Kandpal[2] , B.G. Hanumantharaya[3], Shruthi K.[1] and Priya R.U.[1]
[1]ICAR Agricultural Technology Application Research Institute (ICAR-ATARI), Zone-11, Bengaluru, Karnataka, India
[2]Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Bengaluru, Karnataka, India
[3]ICAR-Krishi Vigyan Kendra (KVK) in Hadonahalli, Doddaballapura taluk, Bengaluru Rural District, Karnataka, India
E- mail: budensha37@gmail.com
(Date of Receiving : 17-09-2025; Date of Acceptance : 26-11-2025)

ABSTRACT

The high cost of sucrose in tissue culture media poses a major challenge for large-scale tissue culture, particularly in developing countries. This study evaluated table sugar and jaggery as alternative carbon sources for *in vitro* microtuber production in two potato cultivars, Kufri Himalini and Kufri Jyoti. Potato explants were cultured on MS medium supplemented with sucrose (50 g/L, control), table sugar (40, 50 and 60 g/L), and jaggery (40, 50 and 60 g/L). Results revealed that sucrose (50 g/L) recorded the highest percentage of microtuberizing plantlets (81.90 in Kufri Himalini and 63.40 per cent in Kufri Jyoti). Table sugar at 60 g/L performed on par with sucrose, recording 81.50 and 62.50 per cent microtuberization in Kufri Himalini and Kufri Jyoti, respectively, with comparable microtuber number, size, and weight. In contrast, jaggery failed to induce microtubers in either cultivar, likely due to impurities and organic acids affecting pH stability and nutrient availability. Cost analysis demonstrated that replacing sucrose with table sugar reduced media cost by 29.93 per cent, without compromising efficiency. The findings suggest that table sugar is a viable and cost-effective substitute for sucrose in potato microtuber production, enhancing the affordability of seed potato propagation systems.
***Keywords*:** Potato, Table sugar, Jaggery, Kufri Himalini, Kufri Jyoti, Tissue culture, Low-cost.

Introduction

Potato (*Solanum tuberosum* L.), native to the Andes, remains a cornerstone of global vegetable agriculture, ranking as the third most important food crop after rice and wheat, it occupies the largest area among vegetable crops. India produced over 60.18 million tonnes of potatoes from 2.3 million hectares, with an average yield of 25.79 tons per hectare (Anon., 2025). Potato occupies premier place in the list of vegetable crops in the world including India.

Potato (*Solanum tuberosum* L.) belongs to the family *Solanaceae* and has a chromosome number of 2n = 48. It is one of the most important food crops worldwide, providing carbohydrates, proteins, vitamins, and minerals, and serving as a staple food in many countries (Srikanth *et al.,* 2023). Unlike many other crops, potato can be propagated both sexually through true potato seed (TPS) and vegetatively through tubers.

In practice, however, tuber-based propagation is the predominant method across most potato-growing regions, including India. Seed tubers represent a major input cost in potato cultivation, as approximately 2–3 tonnes are required to plant one hectare, accounting for nearly 40–50 per cent of the total production cost (Simmonds, 1997; Struik and Wiersema, 1999; Pandey and Sarkar, 2005). Beyond the high cost and large quantity of seed required, the use of virus-free tubers is another critical challenge. Only when healthy, disease-free planting material is available can potato cultivars achieve their true yield potential.

Tissue culture (TC) technology plays a crucial role in producing quick, disease-free, and high-quality planting material, which is essential for improving crop yields. This approach has contributed significantly to

addressing challenges of food security and sustainable agricultural production (Ogero *et al.,* 2012). In particular, micropropagation has emerged as an effective alternative to overcome limitations associated with conventional seed production systems (Singh *et al.,* 2019). In potato, micropropagation serves as the foundation of modern seed production programs by supplying nuclear stock in the form of *in vitro* plantlets or microtubers. These serve as the starting material for advanced seed multiplication techniques, including aeroponics, apical rooted cuttings, and mini-tuber production under both soil-based and soilless systems (Chindi *et al.,* 2014; Bharath and Raju, 2023).

However, TC has high operating costs, especially in developing nations, making the technology inaccessible to smallholders (Saraswathi *et al.,* 2016). Production cost limit the scope of economic application of micropropagation. The expense of nutrient medium can account for 30 to 35 per cent of micropropagated plant production (Gitonga *et al.,* 2010). In order to make TC more accessible and advantageous for farmers, alternative low-cost resources are required due to the high cost of production, particularly in medium preparation.

To reduce the unit cost of plant propagules low cost micropropagation was practiced (Savangikar *et al.,* 2002). Reducing the cost of media had a huge effect on horticulture and agriculture sector especially in developing countries (Petrovski and Tilette, 2012).

Sucrose is the preferred carbohydrate for most studies due to its ability to be easily translocated and its resistance to enzymatic degradation, owing to its non-reducing nature (Pontis, 1978). While sucrose is commonly used in the vast majority of *in vitro* shoot induction and development studies in woody species, it is not always the most effective carbon source (Thomson and Thorpe, 1987). Additionally, the high cost of sucrose, which accounts for 21.7 to 30 per cent of the media cost (Prakash *et al.,* 2004; Demo *et al.,* 2008; Swamy *et al.,* 2010; Dantas *et al.,* 2021).

Considering the importance of finding alternative sucrose source for the mass multiplication of potato microtubers, the experiment was designed to find an inexpensive sucrose source for *in vitro* potato plantlet microtuber production.

Materials and Method

This experiment was conducted at the Plant Tissue Culture Laboratory, Department of Horticulture, University of Agricultural Sciences, Bangalore, with the objective to examine the effectiveness of alternative sucrose and vitamin source for *in vitro* potato microtuber production. The three carbon sources, used for experiment were sucrose table sugar, jaggery and sucrose being used as stranded carbon source used for this experiment.

Table sugar is a crude sucrose derived by crushing and extraction of sugarcane (*Saccharum officinarum*). Sugar is hard, white, dry crystals, lumps or powder, sweet taste, odourless soluble in water and very slightly soluble in alcohol (Arthur and Rose, 1996). Raw cane sugar contains 96 to 97 per cent sucrose, 0.75 to 1.0 per cent reducing sugar, 0.75 per cent moisture, 0.5 per cent ash and remainder, organic non-sugars (Anon., 1972). In the present study, the medium was supplemented with common grade sugar (DMart Yelahanka, Bengaluru, India) at 40, 50 and 60 g/L of the medium for microtuber production.

Jaggery is the product obtained on concentrating sugarcane juice with or without prior purification, into a solid or semi solid state. It is also called gur, contains all the constituents of cane juice, some of them having undergone slight changes during boiling. Per cent composition of gur is: sucrose, 65 to 85; invert sugar, 10-15; ash, 2.5; and moisture, 3 to 6. It also contains carotene, 280 I.U./100 g.; nicotinic acid, 1.0 mg./100 g.; vitamin B1, 20 ug/100 g.; and traces of iron and copper (Anon., 1957). In the present study, the medium was supplied with jaggery (DMart Yelahanka, Bengaluru, India) at 40, 50 and 60 g/L of the medium for microtuber production.

Unlike the normal potato tubers and minitubers which are produced underground from the modified stem called the stolons, the microtubers are produced on the nodal region of *in vitro* grown plants. These microtubers are very small compared to minitubers and normal tubers. These microtubers are generally produced when the *in vitro* grown potato plantlets continued to be in the nutrient media for little longer period, generally for about 45 days and beyond cultured. The culture bottles were kept in growth room having temperature of 24 ± 2 ℃. Light intensity of 2000 lux was provided using white fluorescence tubes for eight hours of light and 16 hours dark period (Fig. 1).

The complete data was analysed using CRD. The critical difference of the experimental data was tested by using F test at 1 per cent level of confidence. The analysis was done using OPSTAT online analysis tool.

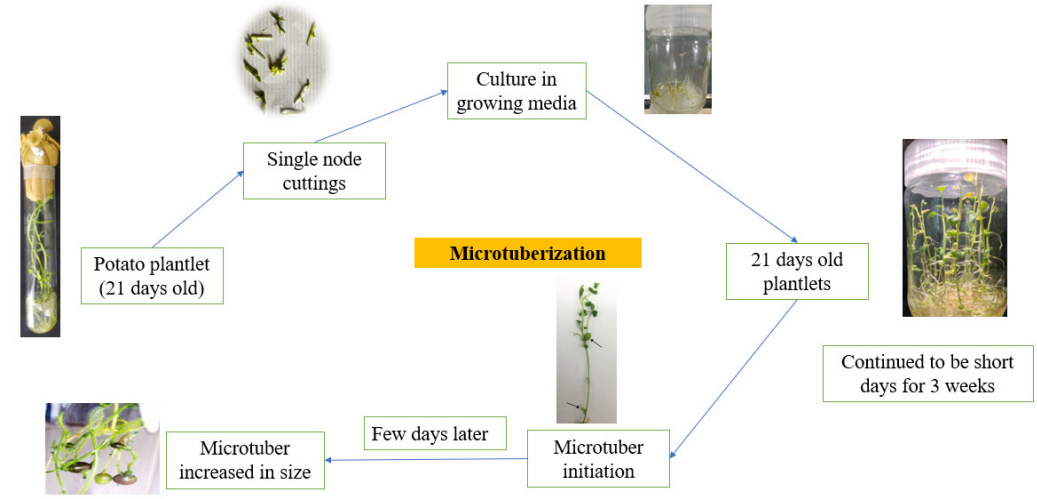

Fig. 1: Schematic representation of different steps involved in potato microtuber production in potato

Treatment Details

Table 1: Alternative sucrose used *in vitro* potato plantlet production

Control: MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm
E_1: MS salts + Agar 6 g/L + Table sugar 40 g/L + BAP 2 ppm
E_2: MS salts + Agar 6 g/L + Table sugar 50 g/L + BAP 2 ppm
E_3: MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm
E_4: MS salts + Agar 6 g/L + Jaggery 40 g/L + BAP 2 ppm
E_5: MS salts + Agar 6 g/L + Jaggery 50 g/L + BAP 2 ppm
E_6: MS salts + Agar 6 g/L + Jaggery 60 g/L + BAP 2 ppm

Results and Discussion

The control treatment (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) demonstrated significantly highest per cent of microtuberizing plantlets (81.90 %) for Kufri Himalini. Similarly, treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) produced comparable results, with 81.50 per cent microtuberization for Kufri Himalini. In contrast, jaggery as a sucrose source failed to induce microtuber in Kufri Himalini, as presented in Table 2. Similarly, for cultivar Kufri Jyoti higher per cent of microtuber inducing plantlets (63.40 %) were recorded in control treatment (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) followed by treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) demonstrated comparable results, with 62.50 per cent microtuber induction for Kufri Jyoti (Table 3), indicating that higher concentrations of table sugar could be a viable substitute for standard sucrose. In contrast, jaggery as a sucrose source failed to induce microtubers.

Table 2: Influence of alternative sucrose sources on growth parameters of *in vitro* potato micro tuber production cv. Kufri Himalini

Treatments	Per cent microtuberizing plantlets (%)	Number of microtubers/ plantlet	Average weight of fresh microtuber (mg)	Average size of microtuber (mm)
Control	81.90 (64.82)	2.31 (1.81)	202.39 (14.26)	5.41 (2.53)
E_1	39.70 (38.99)	0.85(1.34)	142.38 (11.97)	2.67 (1.91)
E_2	57.50 (49.30)	1.35 (1.51)	177.52 (13.36)	3.86 (2.20)
E_3	81.50 (64.60)	2.19(1.78)	201.04 (14.21)	5.09 (2.46)
E_4	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
E_5	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
E_6	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
F-test 1%	**	**	**	**
S. Em ±	0.65	0.11	0.02	0.02
CD at 1%	1.864	0.04	0.07	0.05

Note: Values in the parenthesis are angular transformed
** -Significant at 1% level; **S. Em-** Standard error mean; **CD-**Critical difference

Among the different treatments numerically highest number of microtubers per plantlet (2.31) was recorded in control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) for Kufri Himalini. Comparable results were recorded in treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) with averaging 2.19 microtubers per plantlet for Kufri Himalini. In contrast to these treatments using jaggery

as a sucrose source failed to produce any microtubers, depicted in Table 2.

Similarly, for Kufri Jyoti significantly higher number of microtubers per plantlet (1.95) was recorded in control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm). This was statistically on par with treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) with averaging 1.95 microtubers per plantlet for Kufri Jyoti. In contrary to these treatments using jaggery as a sucrose source failed to produce any microtubers, as presented in Table 3.

Significantly, the maximum fresh weight of microtuber (202.39 mg) was measured in the control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) for Kufri Himalini. Similarly, treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) performed on par comparable results with 201.04 mg fresh weight of microtuber for Kufri Himalini (Table 2). In contrast, media prepared with jaggery as a low cost alternative for sucrose source failed to induce microtubers.

Among the different treatments highest microtuber fresh weight was recorded in treatment control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) with average weight of 169.81 mg for Kufri Jyoti. Similarly, treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) performed on par results with averaging 168.24 mg for and Kufri Jyoti. In contrast, media prepared with jaggery as a low cost alternative for sucrose source failed to induce microtubers, as presented in Table 4.

Significantly larger microtuber (5.41 mm) were recorded in control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) for Kufri Himalini (Table 3). This was statistically on par with treatment E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) with averaging 5.09 mm microtuber size for Kufri Himalini. However, media prepared with jaggery as a low cost alternative for sucrose source failed to induce microtubers.

Among the different treatments significantly larger microtuber (4.76 mm) was recorded in control (MS salts + Agar 6 g/L + Sucrose 50 g/L + BAP 2 ppm) for Kufi Jyoti. This was statistically showed on par results with E_3 (MS salts + Agar 6 g/L + Table sugar 60 g/L + BAP 2 ppm) with averaging 4.63 mm microtuber for Kufri Jyoti. Conversely, media prepared with jaggery as a low cost alternative for sucrose source failed to induce microtubers, as presented in Table 4.

Potato explants cultured on media prepared using jaggery as an alternative caron source resulted in no microtuber initiation reason might be due to the presence of organic acids and other compounds in jaggery can resulted in fluctuating pH level, which can negatively affect enzyme activity and nutrient availability during the process of tuber induction, these results are in line with Agarwal *et al.* (2010) in banana.

The reason for microtuberization using table sugar as a sucrose source might be due to the efficient translocation and assimilation of table sugar by explants leading to enhanced cell division and eventual growth which is similar to sucrose. Similar findings were reported in banana (Ganapati *et al.,* 1995; Saeed, 2006; Das and Gupta, 2009).

In contrast, media prepared jaggery as a sucrose failed to induce any microtuber in both cultivars (Kufri Himalini and Kufri Jyoti). This can be attributed to the impurities and inconsistent composition of jaggery, which likely disrupted the nutrient balance in the medium, there by inhibited tuber formation.

Table 3: Influence of alternative sucrose sources on growth parameters of *in vitro* potato micro tuber production cv. Kufri Jyoti

Treatments	Per cent microtuberizing plantlets (%)	Number of microtubers/ plantlet	Average weight of fresh microtuber (mg)	Average size of microtuber (mm)
Control	63.40 (52.75)	1.95 (1.71)	169.81 (13.06)	4.76 (2.40)
E_1	29.40 (32.81)	0.79 (1.33)	117.25 (10.87)	2.49 (1.86)
E_2	47.20 (43.37)	1.20 (1.50)	148.57 (12.23)	3.55 (2.13)
E_3	62.50 (52.22)	1.81 (1.67)	168.24 (13.00)	4.63 (2.38)
E_4	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
E_5	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
E_6	0.0 (0.00)	0.0 (1.00)	0.0 (1.00)	0.0 (1.00)
F-test 1%	**	**	**	**
S. Em ±	0.27	0.01	0.02	0.027
CD at 1%	0.77	0.04	0.06	0.09

Note: Values in the parenthesis are angular transformed

** -Significant at 1% level; **S. Em-** Standard error mean; **CD-**Critical difference

Cost Analysis

The cost analysis for MS-media and modified media for *in vitro* potato microtuber production is summarized in Table 4.

The total cost for preparing one litre of standardized media (MS- salts + Agar 6 g/L + Sucrose 50 g/L+ BAP 2ppm) was approximately about Rs. 184.14, while the total cost for the modified media [MS-salts + Agar 6g/L + Table sugar 60 g/L +BAP 2ppm] was significantly reduced to Rs. 129.02 (approximate) for potato microtuber induction. This demonstrates a cost reduction of 29.93 per cent in media preparation cost for potato microtuber production.

These findings were in accordance with Mohamed *et al.* (2010), Prabhuling and Satyanarayana (2013) and Ullah *et al.* (2013). They reported that, cost of media can be reduced by using different alternatives for *in vitro* production of potato, banana and orchid, respectively.

Table 4: Cost analysis of MS-media and modified media for *in vitro* potato microtuber production

Constituents	Stock-A (Rs.)	Stock-B (Rs.)	Stock-C (Rs.)	Stock-D (Rs.)	Agar (Rs.)	Sucrose (Rs.)	BAP (Rs.)	Total cost (Rs.)
Control	7.30	0.34	0.29	2.61	68.40	58.00	47.20	184.14
Modified Media	7.30	0.34	0.29	2.61	68.40	2.88	47.20	129.02
Per cent Reduction	-	-	-	-	-	87.35	-	29.93

Control: MS- salts + Agar 6g/L + Sucrose 50 g/L+ BAP 2ppm
Modified media: MS-salts + Agar 6g/L + Table sugar 60 g/L + BAP 2ppm

Conclusion

The results of the present study highlight the potential of utilizing cost-effective alternative media components for *in vitro* mass multiplication of potato microtubers. Substituting the conventional, costly sucrose source with the more affordable option of table sugar significantly reduced production costs, while maintaining the efficiency of microtuber development.

References

Agrawal, A., Sanayaima, R., Tandon, R. and Tyagi, R.K. (2010). Cost-effective in vitro conservation of banana using alternatives of gelling agent (isabgol) and carbon source (market sugar). *Acta Physiologiae Plantarum*, **32**(4), 703-711.

Anonymous (1957). The Wealth of India-A Dictionary of Indian Raw Materials and Industrial Products. Vol. IV, Published by Council of Scientific and Industrial Research, New Delhi.

Anonymous (1972). The Wealth of India-A Dictionary of Indian Raw Materials and Industrial Products. Vol. IX, Published by Council of Scientific and Industrial Research, New Delhi.

Anonymous (2025). Ministry of Agriculture and Farmers' Welfare. *Second Advance Estimates of Horticulture Production* 2024–25.

Arthur and Rose, E. (1996). The Condensed Chemical Dictionary. 5th Edition, Reinhold Publishing Corporation, New York, pp: 227.

Bharath, S.R. and Raju, B.M. (2023). Optimization of photoperiod, carbon source and plant hormones for effective micro-tuberization in potato. *Mysore J. Agric. Sci.*, **57**(1): 127-138.

Chindi, A., Giorgi, G. W., Atsede, S., Lemma, T. and Negesh, K. (2014). Rapid multiplication techniques (RMTs): A tool for the production of quality seed potato (*Solanum tuberosum* L.). *Asia. J. Crop Sci.,* **6**(3): 176-185.

Das, A. and Gupta, S.N. (2009). Use of low cost resources for banana micropropagation. *Indian J. Hortic.,* **66** (3): 3-15.

Dantas, L.A., Faria, P.S.A., Dário, B.M.M., Arantes, A.L.M., Silva, F.G., Avila, R. G., Pereira, P.S. and Neto, A.R. (2021). The impact of carbon source on cell growth and the production of bioactive compounds in cell suspensions of *Hancornia speciosa* Gomes. *Sci. Rep.*, **11**(1): 1-14.

Demo, P., Kuria, P., Nyende, A.B. and Kahangi, E.M. (2008). Table sugar as an alternative low cost medium component for *in vitro* micropropagation of potato (*Solanum tuberosum* L.). *Afr. J. Biotechnol.*, **7**(15): 2578-2584.

Ganapathi, T.R., Mohan, J.S.S., Suprasanna, P., Bapat, V.A. and Rao, P.S. (1995). A low-cost strategy for *in vitro* propagation of banana. *Curr. Sci.*, **65** (6): 646-650.

Gitonga, N.M., Ombori, O., Murithi, K.S.D. and Ngugi, M. (2010). Low technology tissue culture materials for initiation and multiplication of banana plants. *Afr. Crop Sci. J.*, **18** (4): 243-251.

Mohamed, M.A.H., Alsadon, A.A. and Mohaidib, M.S. (2010). Corn and potato starch as an alternative for *Solanum tuberosum* micropropagation. *Afri. J. Biotech.,* **9** (1): 12-16.

Ogero, K. O., Mburugu, G. N., Mwangi, M., Ngugi, M. M. and Ombori, O. (2012). Low cost tissue culture technology in the regeneration of sweet potato (*Ipomoea batatas* (L) Lam). *Res. J. Biol.*, **2** (2): 51-58.

Pandey, S.K. and Sarkar, D. (2005). Potato in India: Emerging trends and challenges in the new millennium. *Potato J.,* **32** (3): 93-104.

Petrovski, S. and Tillett, D. (2012). Back to the kitchen: food-grade agar is a low cost alternative to bacteriological agar. *Anal. Biochem.*, **429** (2): 140-141.

Pontis, H.G. (1978). On the scent of riddle of sucrose. *Trends in Biochem. Sci.,* **6**: 137-139.

Prabhuling, G. and Sathyanarayana, B.N. (2017). Cheaper carbon sources for micropropagation of banana cv. 'Grande Naine'. *Int. J. Agric. Sci.,***13** (1): 124-131.

Prakash, S., Hoque, M. I. and Rrinks, T. (2004). Culture media and containers. In: Low cost options for tissue culture technology in developing countries. *Proc. Tech. Meet.,* 26-30 August, Vienna.

Saeed, B.A. (2006). *In vitro* selection and evaluation of genetic purity of regenerated banana plants. Ph.D. Thesis, *Univ. Karachi*, Karachi.

Saraswathi, M.S., Uma, S., Kannan, G., Selvasumathi, M., Mustaffa, M.M. and Backiyarani, S. (2016). Cost effective tissue culture media for large scale propagation of three commercial banana (*Musa* spp.) varieties. *J. Hort. Sci. Biotechnol.,* **91** (1): 23-29.

Savangikar, V.A., Savangikar, C., Daga, R.S. and Pathak, S. (2002). Reduction in cost in micropropagation: Achievements and further prospects, In Ist International Symp. Liquid system for *in vitro* mass propagation of plants, Ahrensburg, Germany, pp: 29.

Simmonds, N.W. (1997). A review of potato propagation by means of seed, as distinct from clonal propagation by tubers. *Potato Res.,* **40** (2): 191-214.

Singh, R.K., Buckseth, T., Tiwari, J.K., Sharma, A.K. and Chakrabarti, S.K. (2019). Recent advances in production of healthy planting material for disease management in potato. *Biotech. Today.: Int. J. Bio. Sci.,* **9** (1): 7–15.

Srikanth, G.S., Nagaraju, K. and Muthuraju, R. (2023). Isolation and screening of bacterial endophytes against *Alternaria solani*-causing early blight disease in potato (*Solanum tuberosum* L.). *Mysore J. Agric. Sci.,* **57**(1): 360-366.

Struik, P.C. and Wiersema, S.G. (1999). Seed Potato Technology. Wageningen Pers, Wageningen, the Netherlands, pp. 383.

Swamy, M.K., Sudipta, K.M., Balasubramanya, S. and Anuradha, M. (2010). Effect of different carbon source on *in vitro* morphogenetic response of patchouli (*Pogostemon cablin* Benth.). *J. Phytol.,* **2**(8): 11-17.

Ullah, M.A., Uddin, M.I., Haque, M.S., Rajib, R.R. and Haque, M.A. (2013). Corn and potato starch as cost effective alternative gelling agents for *in vitro* propagation of orchid. *Intl. J. Bio. Res.,* **15**(6): 4-11.