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Rapid Multiplication Technique For Production Of High-Quality Seed Potato (*Solanum tuberosum* L.) Tubers

Ravindra Awati, Anjanabha Bhattacharya*, Bharat Char

Maharashtra Hybrid Seeds Company Private Limited (Mahyco), Jalna - Aurangabad Road, Jalna, Maharashtra 431203, India.

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ABSTRACT

Potato farmers in India and other developing countries lack timely availability of healthy and good quality potato seed tubers. This is mainly due to conventional seed multiplication techniques which, has suffered inherently from low multiplication rates. The soil medium is generally used for seed tuber production. In order to overcome bottlenecks, a study was conducted to evaluate mini-tuber production potential for selected baskets of potato varieties in different soil-less solid media types compared with soil as a control. Soil-less media technique would also assist in planning for economical and rapid seed multiplication program, along with pathogen-free seed tubers, which will increase production of good quality reliable seed material in the country. This will finally ensure increased productivity of potato crop. With these objectives, an experiment was conducted during the years, 2015–2016 and 2016–2017. Three different soil-less solid propagation media (kalpeat plus, soilrite mix and soilrite mix TC) were tested against control (soil:sand 3:1); for five different varieties (1001, 1002, 1003, 1004 and 1005). Plantlets grown on soilrite mix performed better with higher mini-tuber yield of 548.58 gm/container (1/2 m²), while for other propagation media, 283.39 gm/container (1/2 m²), 96.08 gm/container (1/2 m²), and 52.61 gm/container (1/2 m²) respectively, were observed for kalpeat plus, soilrite mix TC and control (soil:sand 3:1). Among the varieties tested, *viz.,* 1005 and 1004 produced maximum mini-tubers, between 9 tubers/plant and 5 tubers/plant respectively. Soilrite mix increased the number and size of mini-tubers. Thus, this study concluded that soil-less solid media induced seed potato multiplication is better than traditional soil-based techniques.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.), being a predominantly vegetatively propagated crop, is subject to large number of seed and soil-borne diseases, responsible for lower than expected yield. Hence, good quality healthy planting material (seed tubers) has essential role to play in sustainable and economical production of potato crop. In India, conventional seed production is popularly used, which involves tuber indexing for virus. The clonal multiplication could take 7 years and more, that is an impediment to increase supply of good quality planting material. Moreover, the currently used method has low multiplication rate (1:6) [4,14] and therefore, it is expensive and time consuming to produce enough seed tubers to meet seed tuber demand in the market. It is estimated that the cost of seed tuber may account for almost, 40% of the production cost of commercial potato production [13]. Virus infection reduces potato production drastically. Over time, virus replicons tend to increase in the seed material during field multiplication cycles, and therefore yield crash. In order to avoid viral diseases, tuber indexing, a new system has been established for producing healthy seed tuber-based on systemic virus testing and *in vitro* rapid multiplication of virus-free planting material [3, 18]. In addition, multiplication take place in field (soil), thereby exposing the seed potatoes to plethora of soil-borne disease. Soil is the main platform for pest and disease infections to spread, resulting in significant loss of yield and deteriorate tuber quality over seasons [19]. To address this soil-borne disease problem, soil-less culture can be introduced successfully [5]. Soil-less technology involves growing plants in soil-less condition with their roots in mineral nutrient medium which, is generally inert material (solid media) and involving systems like hydroponics, aeroponics. Soil-less culture has capability to grow plants in a conditioned, pest and disease free environment [10].

The solid media is one of the most important factors for production of clean seed tuber material. In case of material grown in containers, as in the present study, considering the relatively shallow depth and the limited volume of container, solid media must be amended to enhance the appropriate physical and chemical properties necessary for robust

*Corresponding Author
Anjanabha Bhattacharya, Maharashtra Hybrid Seeds Company Private Limited (Mahyco), Jalna - Aurangabad Road, Jalna, Maharashtra 431203, India. E-mail: anjanabha.bhattacharya @ mahyco.com

plant growth. The solid media has gained more and more popularity, as they eliminate or reduce the need for soil disinfestations. Among soil-less solid media, rock wool has been widely used in Europe, while in tropic and subtropics considering economy, cheaper substrates have been exploited [16]. Although, research has shown that different media (perlite, peat, sand, compost, and styrofoam) can be used to grow *in vitro* potato plants in a greenhouse [4]. Some of these solid media were very expensive and/or substrate alone, is not suitable in one or other way, for tuber production factors, like, aeration, drainage and water holding capacity, which is limited. Due to this high cost and impediments associated with such media types, other alternatives can be used which, are cheap and easy to use. There is also scarce information available on production of seed tubers of Indian varieties on soil-less media, using *in vitro* plantlets in the greenhouse.

Therefore, a study was conducted to evaluate, the growth and yield response, of *in vitro* potato plantlets of Indian varieties in different solid media (a mixture of the substrate) in order to optimize and produce good quality clean seed potato production (multiplication).

2. MATERIALS AND METHODS

The study was conducted in the greenhouse of Maharashtra Hybrid Seed Co. Pvt. Ltd. Jalna, during years 2015–2017. A total three seasons, October 2015 to January 2016; June 2016 to September 2016; and October 2016 to January 2017, was taken to evaluate appropriate conditions for economical and good quality mini-tuber production.

2.1. Plant Material

The virus-free mother stock of five local varieties *viz.,* 1001, 1002, 1003, 1004 and 1005.

2.2. Solid Media

Three solid propagation media were used namely; kalpeat plus, soilrite mix and soilrite mix TC and control soil:sand (3:1) which were commercially available {manufactured and supplied by Keltch Energies Ltd, Bangalore}. The details of the solid media used, composition, pH, and cost are mentioned in table 1.

Table 1: Characteristics of different solid media.

Sr. no	Solid media	pH	Composition	Cost per Kg in Rs.
1	Kalpeat plus	5.5-6.0	Coco peat:Perlite (75:25)	32
2	Soilrite mix	6.0-6.5	Peat moss:perlite:vermiculite (1/3:1/3:1/3)	52
3	Soilrite mix TC	6.0-6.5	Peat moss:perlite (75:25)	60
4	Control	6.5-7.0	Black Soil:Sand (75:25)	5

The treatments were arranged in a completely randomized block design (CRBD) with three replicates. The experiment involved two factors: one-factor being media which, is composed of three solid media and a control (commonly used for growth media, soil + sand). Second factor composed of five Indian potato varieties, two early maturing varieties - 1003, 1005 and three medium maturing varieties - 1001, 1002, 1004. Rooted, *in vitro,* potato plantlets, were transplanted to the greenhouse in containers [120 × 60 × 30 cm^3 (1/2 m^2)] filled with respective solid media (40 lit/container), at a spacing of 10 × 10 cm, which corresponds to 25 plants per container [6,7].

For all above treatments following protocol was used. Just before planting, a half dose of nitrogenous fertilizer, a full dose of phosphate and potash as 8:6:7 gm/m^2 as recommended by CPRI Shimla was applied through ammonium sulfate, single super phosphate, and muriate of potash respectively. Micneff 16, a micronutrient fertilizer, was also applied before planting. After transplanting, *in vitro* plants were watered immediately with 19:19:19 mixed foliar fertilizer at the rate of 0.5 gm/liter. For the first two months, to get better vegetative growth, 19:19:19 fertilizer was applied to soil at the rate of 0.5 gm/lit/week. Thereafter, at least for two months, foliar fertilizer, 0:52:34, at the rate of 1 gm/lit was applied every two weeks.

In case of plant protective measures, every two weeks the plants were sprayed with pesticide solutions. In one liter of water, following were added, 9 gm of Dithane M 45 or 3.5 gm Ridomil gold MZ fungicide and 4.4 ml Metasystox or 0.5 mg Admir insecticide. The solution prepared was used half strength, for the first one month and full strength for the rest of the season. As the plants in the blocks grew, they were supported by thread and banding wires.

The haulms were destroyed manually on 120 days after planting. The pooled data collected were statistically analyzed, using randomized block design. The data collected included *in vitro* plant survival % after three weeks of transplanting. Mini-tuber yield was determined by weighing the weight of tubers in grams, per container (1/2 m^2) and tuber number per plant were determined by manual counting.

3. RESULTS AND DISCUSSION

3.1. Effect of Solid Media Type and Varieties on the Survival % of *In Vitro* Plantlets after Three Weeks of Transplanting

Higher plant survival and establishment percentage of 96% was observed in varieties planted in kalpeat plus, followed by soilrite mix (89.6%), soilrite mix TC (86.2%) which was significantly more than in control (soil + sand) media, which recorded 79.2% germination. This could be due to improved aeration, soil water absorbing capacity, composition variables and characteristic of the soil-free medium than in control media. The germination percentage varied, among tested varieties (79–94.75%) and the observation recorded varied due to varietal/genotype differences/attributes, post three weeks transplanting. However, the interaction between genotype and soil media at the stage of germination seems insignificant [9]. This could be due to strong genotypic differences between the varieties used in the present study which seem to be at par with each other, over the various medium used in the study. Media differences are significant over control (Table 2).

In the present study, all the solid media and control used were supplemented with similar rate and type of fertilizers. Apart from being influenced by varietal or genetic composition, high plant establishment percentage is also influenced by the type of solid media used among other environmental factors [15].

3.2. Effect of Solid Media Type and Varieties on the Potato Plant Height

There was a significant variation among the interactions between variety and solid media. 1004 and 1005 plants showed the highest height of 110 cm and 120 cm respectively, while 1002 plants showed lowest plant height growth of 30 cm (figures 1 & 2). The varieties grown in kalpeat plus and soilrite mix media had more heightened plant than that in soilrite mix TC and control. It could be because of solid media, kalpeat plus and soilrite mix composition which, retains nutrients better to boost plant height under greenhouse condition. This shows kalpeat plus and soilrite mix are good solid media for potato mini-tuber production as more heightened healthy plants had more

photosynthetic area translating to higher yield. Our observed results are in consonance with similar published reports which, showed that a well-established root and shoot system, is important for subsequent growth which, in turn, influences tuber bulking in potato [8].

Table 2: Effect of solid media type and genotype on the survival % of *in vitro* plantlets after 25 days of transplanting.

Sr. no	Genotype	Solid media type				Mean for Genotype
		Control Soil:Sand	Kalpeat plus	Soilrite Mix	Soilrite Mix TC	
1	1001	62.00 ± 1.5	98.00 ± 1.5	80.33 ± 1.8	76.66 ± 0.66	79
2	1002	80.33 ± 1.8	91.66 ± 1.2	84.66 ± 1.7	79.66 ± 0.33	83
3	1003	89.00 ± 2.5	100.00 ± 00	92.00 ± 1.1	89.66 ± 0.88	92.5
4	1004	91.66 ± 1.2	100.00 ± 00	96.66 ± 0.6	92.33 ± 0.88	94.75
5	1005	74.00 ± 1.1	91.66 ± 1.2	96.66 ± 0.6	80.00 ± 1.1	85.9
Mean for media type		79.2	96	89.2	86.2	

Values in the table are presented with mean ± standard error.

Table 3: Effect of solid media type and genotype on average mini-tuber yield gram per block (per 1/2 m²) at time of harvest.

Sr. no	Genotype	Solid media type				Mean for Genotype
		Control Soil:Sand	Kalpeat plus	Soilrite Mix	Soilrite Mix TC	
1	1001	80.66 ± 4.05	96.00 ± 4.30	200.00 ± 5.50	60.00 ± 2.50	109.16
2	1002	15.66 ± 0.33	200.00 ± 3.21	448.60 ± 7.50	80.00 ± 0.57	186.31
3	1003	30.33 ± 0.33	460.66 ± 11.83	472.33 ± 7.79	60.34 ± 2.72	255.91
4	1004	120.40 ± 7.85	420.00 ± 7.65	1004.67 ± 5.78	200.00 ± 5.92	436.26
5	1005	15 ± 1.0	240.30 ± 11.55	592.34 ± 5.54	80.00 ± 1.15	231.91
Mean for media type		52.61	283.39	543.58	96.08	

Mean in the main effects have been compared separately.

Table 4: Number of mini-tuber per plant as affected by solid media type and genotype.

Sr. no	Genotype	Solid media type				Mean for Genotype
		Control Soil:Sand	Kalpeat plus	Soilrite Mix	Soilrite Mix TC	
1	1001	2 ± 0.72	3 ± 0.57	2 ± 0.41	1 ± 0.16	2
2	1002	1 ± 0.16	2 ± 0.52	3 ± 0.37	2 ± 0.58	2
3	1003	1 ± 0.33	4 ± 0.66	3 ± 0.60	1 ± 0.03	2.25
4	1004	3 ± 0.35	4 ± 0.49	5 ± 0.49	3 ± 0.35	3.75
5	1005	1 ± 0.33	5 ± 0.54	9 ± 0.35	3 ± 0.52	4.5
Mean for media type		1.6	3.6	4.4	2	

Values in the table are presented as a mean ± standard error, Mean in the main effects have been compared separately.

3.3. Effect of Solid Media Type and Varieties on Mini-Tuber Yield {Gram per Container (1/2 m²)} at the Time of Harvest

There was a significant interaction between varieties and solid media with respect to a yield of 1004 and 1005, transplanted in soilrite mix which produced relatively higher yield [1004.67 and 592.34 gram respectively per container] (1/2 m²) among the five varieties tested. However, the results were different for varieties planted in kalpeat plus; 1003, 1004 and 1004 which, were having a higher yield of 460.66 and 420.0 gram per container (1/2 m²) respectively (Table 3). The variation in yield per variety could be attributed to the influences boosted by media type and varietal genetic composition. This results in different potato varieties adapted differently to planting bed (solid media type), which were in consonance with a report by as in [12]. Yields were lower in soilrite mix TC and control, which correlated with poor plant growth. The observation seen could be due to photosynthetic area differences that effect tuber formation of potato plant (Figure 3). The main role played by physical characteristics of solid media is can be attributed as suitable air-filled porosity, for effective oxygen diffusion and maintaining favorable water content for supplying water, nutrient, and respiration of plant roots [17]. These results show that for high multiplication of mini-tuber in greenhouse, solid media is an important factor, to be considered as it affects both growth and mini-tuber yield of potato.

3.4. Number of Mini-Tuber per Plant as Affected by Solid Media and Varieties

There was a significant interaction between varieties and solid media with respect to the number of tuber per plant (Table 4). 1005 and 1004 plants planted in soilrite mix, registered the highest number of tuber per plant, 9 and 5 respectively, followed by 5 and 4 tubers per plant in kalpeat plus media respectively. Researchers [1,12] reported that tuber number rather then tuber weight is important for reporting yield in greenhouse production. 1005 and 1004 varieties recorded a higher number of tuber per plant indicating superiority over other varieties. This could be because of interaction between the genetic constitution of varieties and environment, which could have translated to a higher number of mini-tuber per plant. These results indicate higher multiplication rate potential of these varieties in the greenhouse.

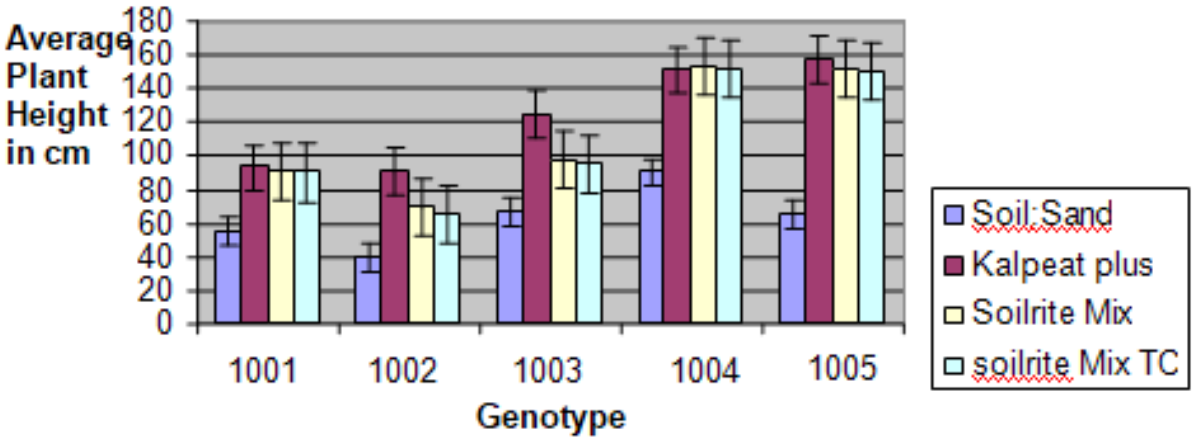

Figure 1: Effect of solid media type and genotype on plant height.

Figure 2: Systematic over-view of quality seed potato production on soil-less beds of solid media (at the time of transplanting) A1: Control, A2: Kalpeat plus, A3: Soilrite mix and A4: Soilrite Mix TC.

Figure 3: Systematic over view of quality seed potato production on soil-less beds of solid media of 70 day old plants A1: Control, A2: Kalpeat plus, A3: Soilrite mix and A4: Soilrite Mix TC.

Research group [2] reported that nutrient uptake of plants is determined by growth media (solid media). Soilrite mix despite being expensive is still the best media indicating its superiority among the other media used. This could be attributed to its ability to hold and retain nutrients which are available to the plants. This result shows that mixture of two or three different substrate media like soilrite mix, kalpeat plus etc. are better for soil-less solid media production than using vermiculite, perlite etc. which may provide same results also reported as in [11]. The present study, therefore, indicates that with good manipulation and management of other alternative media tested such as kalpeat

plus, could equally do well in mini-tuber production as soilrite mix. Therefore, better agronomic techniques can decrease the use of more expensive media and thus less expensive soil-less media can be used.

4. CONCLUSION

The results have shown that mini-tuber yield among varieties under greenhouse condition varies with higher survival percentage of transplanted seedlings. Vigorous growth in soil-less media represents a potential for establishment and production of potato mini-tuber in an economical way, by reducing cost per tuber production, and also increasing tuber weight, number, and viability. The results have also shown that performance of potato varieties vary with propagating solid media under contained greenhouse conditions. Among the media type used, the soilrite mix was found to be superior in supporting plant growth and tuber formation, followed by kalpeat plus. The study has provided valuable information on soil-less media and the role it plays in increasing productivity of seed tuber in perspective of commonly used Indian potato varieties. This will act as a benchmark for potato mini-tuber production research and up-scaling programs for making available pathogen-free seed tubers, with least cost, and therefore, will facilitate increased potato production in India.

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6. REFERENCES

1. Alsadon AA, Knutson KW. Field and greenhouse tuberization of six potato cultivars grown from *in vitro* plantlets. Agric Sci 1994; 6:79-86.
2. Asghari-Zakaria R, Maleki-Zanjini B, Sedghi E. Effect of *in vitro* chitosan application on growth and mini-tuber yield of *Solanum tubeerosum* L. Plant soil Environ 2009; 55:252-256.
3. Altindal D, Karadogan T. The effect of carbon sources on *in vitro* Microtuberization of potato (*Solanum tubeerosum* L.). Turk J Field Crops 2010; 15:7-11.
4. Balali GR, Hadi MR, Yavari P, Bidram H, Naderi AG, Eslami A. Effect of pot size, planting date and genotype on mini-tuber production of Marfona potato cultivar. Afr J Biotechnol 2008; 7:1265-1270.
5. Butler JD, Oebker NF. Hydroponics as a hobby-Growing plants without soil. Circular 844. Information office, college of agriculture, university of Illinois, Urbana, IL 61821 2006.
6. Coolong T. Hydroponic Lettuce. Universty of Kentucky Cooperative Extention Service 2012; 1-4.
7. Donnell M, Short T, Moore R, Draper C. 2011. Hydroponic Greenhouse Lettuce Enterprise Budget. Columbus, OH. 28.
8. Dwelle RB, Love SL. Potato growth and development. 2000. Available at http://www.cals.uidaho.edu.
9. Hassanpanah D, Khodadadi M. Study the plantlet age effect and planting beds on agria potato mini-tuber production under *in vivo* condition. J Biol Sci 2009; 9:243-248.
10. Kaur G, Kumar D. Aeroponic Technology: Blessing or Curse. Int J Engi Res & Tech 2014; 3(7):691-692.
11. Khodadadi M, Hassanapah D, Pirovates SP, Masoumi H. Evaluation of different planting beds effects on mini-tuber production of potato cultivars under greenhouse Condition. Amer Eurasian J Agric Environ Sci 2011; 11:365-370.
12. Khurana SMP, Minhas JS, Pandey SK. 2003. The Potato: production and utilization in subtropics. New Delhi, India: Mehta Publishers 445.
13. Kumar P, Singh V, Singh RP, Singh BP and Naik PS. Performance of *in vitro* plantlets for production of mini-tubers in vector free environment. Potato J 2007; 34:131-132.
14. Kumar D, Singh V, Singh BP. Growth and yield of potato plants developed from *in vitro* plantlets in nethouse. Potato J 2011; 38(2):143-148.
15. Kuria P, Demo P, Nyende B, Kahangi E. Cassava starch as an alternative cheap gelling agent for the in vitro micro-propagation of potato (*Solanum tuberosum* L.). Afr J Biotechnol 2008; 7:301-307.
16. Mobini SH, Ismail MR, Arouiee H. Influence of ventilation and media on potato *(Solanum tuberosum* L.) tuberization and its growth characteristics. Afr J Biotechnol 2009; 8:2232-2241.
17. Richard TL, Veeken AH, Wilde V, Hamelers HVM. Air-filled porosity and permeability relationships during solid-state fermentation. Biotechnol Prog 2004; 20:137-138.
18. Singh IP. 2002. Seed production of vegetable crops. Meerut, India: Aman Publication House.
19. Tsoka O, Demo P, Nyend AB, Ngamau K. Potato seed production from in vitro and apical stem cutting under Aeroponic system. Afr J Biotechnols 2012; 11:12612-12618.

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