Manual for
Pre Basic seed production of Potato using Hydroponic & Aeroponic system

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1. Introduction

In Sri Lanka, 80% of the seed potato planted by the farmers is of poor quality, because this seed is produced by farmers themselves without adopting proper technology. Therefore, it is imperative to introduce appropriate technologies to produce high quality seed potato with low cost. Availability of high quality seed potato at right time will increase the productivity and reduce the cost of production.

This manual is aimed to diffuse novel seed potato production technologies; Hydroponic/Aeroponic among farmers for quality seed potato production.

Hydroponic/Aeroponic/Geoponic is growing potato in soilless media for producing pre-basic seed potato using repeated harvesting technique. In these methods higher number of tuber yields (X 10-times or higher), can be obtained when compared to conventional methods.

In conventional method of producing quality pre-basic seed potato, in vitro plantlets are multiplied in an insect proof glasshouse. From this method usually 5 to 10 mini-tubers per plant can be harvested. In this method steam sterilized substrate made of a mixture of various components without soil is used. Steam sterilization eliminates arthropods, nematodes, pathogens and weeds, efficiently without altering physical structure of the substrate.

Though steam sterilization is most reliable method it is highly expensive due to fuel cost compared to chemical methods like methyl bromide, which is now banned in agricultural activities. On the other hand, Metham sodium, and Chloropicrin can also be used for this purpose.

In the Hydroponic system roots are allowed to grow in a tube containing nutrient solution while stolons are allowed to produce tubers in a vertical dark chamber.

In an aeroponic system, the plants are suspended in air with no form of grow media around their root system. The roots of the plant are kept moist in a sealed environment such as a grow chamber with a nutrient-rich water mist. Aeroponics utilizes the vertical space of the greenhouse and air humidity balance to optimize the development of roots, tubers, and foliage.

Aeroponics has the potential to produce higher number of tubers at reduced cost compared to conventional methods or to the other soilless method like Geoponics.

Seeds produced in these methods are of high quality due to the lack of exposure to soil borne diseases and produced in protected environment.

Commercial production of potato seed using aeroponics/Hydroponics is already practiced in Sri Lanka and also in Korea, China and other countries. At Agricultural Research and Development Centre(ARDC), SitaEliya, NuwaraEliya in Sri Lanka more than 100 minitubers/plants is harvested in fabricated Aeroponics system using relatively simple materials. Currently Pre basic mini seed potato tubers are produced in 2400m$^2$ area of Hydroponic and Aeroponic system by Seed & planting Material Division-Sitaeliya. Another 2400m$^2$ of new protected houses are being constructed for producing pre-basic seeds Aeroponically and hydroponically. The operation of this unit will begin in later part of 2018.
In Sri Lanka, ARDC has developed a unique method of pre-basic seed potato production system starting from production of virus indexed *in vitro* plantlets.

Steps involved in pre-basic seed potato production are

1. Production of virus indexed *in vitro* plantlets
2. Production of rooted stem cuttings mini tuber production in insect proof net house
3. Production of Pre-basic seed potato in Hydroponic/Aeroponic/Geoponic system

2. Mini tuber production in insect proof Net House

   2.1 Major requirements of a net house
   
   The insect proof net house should be constructed in an easily accessible with the orientation of east-west in order to provide sufficient lighting during whole day and to minimize heating up of the net house. Roof may be covered with UV treated plastic sheets or polycarbonate sheets to provide natural lighting. Underneath the roof and sides may be covered with appropriate insect proof net with the mesh size of 32. A shade net can be used under the roof for managing the heat during very hot days. A location which is isolated from potato fields, can obtain clean water, electricity and easily accessible is suitable to construct a net house. (Figure 01)

   Ground floor of the net house should be a cemented with good drainage. Surrounding of the net house must be kept clean and intrusion of pest and pathogens in to net house should be prevented. A foot bath which is filled with a disinfectant (Bleach) is essential for a net house and person who is entering the net house should dip their foot/ shoes in the disinfectant.

   ![Figure 01 - Net house](image)

2.2 Net House management and sanitation practices

Strict sanitation measures should be adopted in Conventional seed potato production in the net house and protected houses in order to avoid contamination, infection or infestation. In mini tuber production and pre-basic seed potato production using Hydroponics, Aeroponics or Geoponics, these measures should be of even higher standards and strictly followed.
There should be a well-trained technical officer in-charge for the operations that will also be responsible for maintaining the sanitation.

- The entire net house or protected houses must be properly sealed, so that no insects can enter these production areas.
- A pre-chamber is constructed with rest room, store room for implements, fertilizer, agrochemicals etc. A separate room may be identified for sorting out and storing mini tubers produced.
- Any implements used in the net house or protected house should not be taken out for using in open fields.
- Visitors must not be allowed inside under any circumstances.
- Operators should be identified exclusively to work in these areas. They should not go to open field for any work especially prior to entering the net house or protected house.
- When entering, the pre-chamber door should open first and the main door must be closed. Never open both doors at the same time. There should be a third door for entering the working area
- The operators should wear clean coats and caps; they should clean their hands with liquid soap prior to starting their work. They also can wear disposable gloves to prevent contaminations.
- Disinfectant should be used after handling each plant.
- If any pest or disease outbreak occurs in the net house apply recommended pesticides, sterilize the net house and wait for at least one month before establishing next crop.
- Rain water can be used as the water source for the net house. If you are using water from other source, treat water with 2-4 ppm Ca Hypochlorite, keep for 24 hours and use it. Always use uncontaminated water for every operations.
- Yellow traps, either water filled trays or greased yellow polythene traps can be used to monitor and detect any infestation of insects. If any incidence is observed, apply suitable control measures and close any possible entry points.
- Trays and other items which are used inside the net house should be cleaned with chlorinated water.

Sanitation Rules that should be displaced in the pre-chamber area
- Never open both doors at the same time
- Dip your shoes in the foot bath
- wash your hands with soap
- If plants are to be handled, wash your hands with Na hypochlorite
- Always wear a coat and cap inside
- No foods allowed

2.3 Controlling environmental conditions in a net house
Temperature controlling in a net house is a critical thing for a quality pre basic seed potato production. Monitoring and recording of maximum and minimum temperature inside the net house is very important (maximum 30 °C and minimum 4 °C is suitable for seed potato production). Buildup of high temperatures can be managed using shade nets (Figure 02) during hot weather conditions.
3. Pre basic seed Potato production in a nutshell

Virus indexed *in vitro* Potato mother plants (Figure 03) are free from plant pathogens viz. bacteria, fungi and especially virus. These planting materials are used to produce Rooted Stem Cuttings (RSC) (Figure 04) and then pre basic seed Potato tubers. Pre basic seeds are multiplied in Aeroponic, Hydroponic and Geophonic system (Figure 05, 07 & 08).

Theses Go pre basic seed potato (Figure 08) are with high quality and disease free. Farmers can multiply these Go in their cultivation lands upto 3 generations as seed potato, by following proper seed potato production procedures(Figure 09).

500-600 high quality Go seeds, multiplied in 25m² land, are enough to produce seed required for ¼ acres of land. (Figure 09)
4. Rapid multiplication of potato mother plants in nethouse

- *In vitro* plants are kept in the net house for 24 hours after opening the lids (Figure 10)
- *In vitro* mother plants are carefully removed from the bottle without damaging the roots.
- Adhered gel in root system is washed thoroughly in sterilized water (Figure 11)
- Dip roots in fungicide (eg- Thiram) (Figure 12)
- Plant them in 8” width pot (4 plants/pot) filled with sterilized solid medium(composition of the medium Sand : Coir dust 1:3) (Figure 13)
• Cover pot with transparent polythene. These plants are called primary mother plants (Figure 14)
• 7 days after planting remove the covered polythene (Figure 15) and apply water and Albert solution. (2 g Albert per 1L water)

4.1 Soilless media preparation

This solid medium is required for establishing in vitro mother plants and for planting stem cuttings of potato primary mother plants (Figure 17, 18). Sand: coir dust 1:3 ratio mixture is steam sterilized for 8 hours in an improvised steam sterilizer using an iron barrel.(Figure 16)
4.2 Production and multiplication of RSCs

Stem cuttings can be obtained from 21 days old well grown primary mother plants using blades sterilized with Ca or Na hypochlorite water or 70% ethyl alcohol. Each stem cutting should contain single node with 3 leaves. Immediately after cutting, stem cuttings are dipped in sanitized water until planting to prevent drying.

Cutting blade should be sterilized after obtaining each cutting.

2\textsuperscript{nd} Stem cutting can be obtained 14 days after 1\textsuperscript{st} stem cutting and thereafter in every 10-15 days cuttings can be obtained. In this way, at least 5 stem cuttings from one primary mother plant can be obtained (Figure 19).

After 3-4 months seed tubers can be harvested from these mother plants as well.

4.3 Planting RSC in a solid medium filled trays

56 Cm X 36 Cm X 10 Cm size plastic tray can be filled with 1:3 sand :coir dust medium. Cutting edge is dipped in a rooting hormone powder or liquid and planted in the trays at 3 cmX3 cm distance in pre prepared holes (figure 20, 21, 22, 23).
These trays are covered with polythene for 7 days to maintain high humidity and to prevent drying of stem cuttings (Figure 20). These are called as 2nd mother plants. After 14 days a stem cutting can be obtained from each and every plant. Again, these stem cuttings are planted in a tray containing soilless media.

At least 5 stem cuttings can be obtained from a primary mother plants From 2nd mother plants at least 3 cuttings are taken.

3 months after planting total stem parts are removed from the primary and secondary mother plants and fungicides are applied after removal of stem. Tiny seed tubers are harvested (Figure 24) and stored usually for 3-4 months until they are sprouted.

These seeds can be further multiplied in

1. Aeroponic System
2. Hydroponic System
3. Geoponic System

5. **Aeroponic system**

Aeroponics is a soilless technique for growing plants. The potato plants are raised in a protected poly house which prevents entry of insect pests reducing the risk of virus infection. The roots are suspended in a dark chamber and misted frequently with complete nutrient solution from the bottom using an electric motor at specified time interval. Potato tubers are formed in the stolon ends that can be harvested at 3-4 days interval when those tubers reached the appropriate size. From each potato plant, 90-120 potato mini tubers (G0) can be harvested.

5.1 **Construction of the Aeroponic system in a Polytunnel**

Materials which are required to construct an Aeroponic system in a 125m² poly tunnel is given in table 01 (Page 20).
For an Aerophonic system, table frames are constructed using either wood or iron bars, with 60-100 cm width, 100 cm height and with convenient length (Figure 25). Top and sides of this table is covered with black polythene so that no light is penetrated into the free space. One length wise side should be fixed in such a way that can be opened whenever necessary (Figure 26). Before covering the table top 1x1” wire mesh should be placed on the top. The ground is constructed with cement with appropriate slope so that the excess sprayed liquid solution can be collected towards one end of the table and eventually in to the nutrient solution tank. The cemented floor is also lined with the black polythene.

The nutrient solution tank should be placed below ground level enabling to collect the drained nutrient solution (Figure 27). A water pump with the capacity of 1.5 hp is used for pumping the solution through 32 mm diameter PVC pipe and in inner compartment of the table. (Figure 30) this pipe is reduced to 20mm on which nozzles are fixed. This is to ensure spraying of nutrient solution with high pressure. Spray nozzles are fixed on 20mm pipe at 60 cm interval (Figure 29). These nozzles are used for spraying nutrient solution. A timer is connected to the pumping unit to control spraying interval (Figure 31).
Figure 28  Diagrammatic illustration of the Aeroponic system
Drained off nutrient solution is collected along the slope into tank and reused. A Timer is used to control spraying interval and duration.

5.2 Planting and maintenance in of potato seedlings

5.2.1 Nursery

Well sieved fine sand is sterilized using steam. An improvised steel barrel with water in the bottom can be used for this purpose. Plastic tray of size 56 cm X 36 cm X 10 cm is filled with sterilized sand and sprouted tubers harvested from RSC are planted in it. Irrigation should be done whenever necessary. Two weeks after planting the tubers well grown Potato seedlings are ready for planting in Aeroponic system (Figure 32). These seedlings are carefully uprooted from the nursery, washed with clean water, dipped in a fungicide solution (eg- Homai, Thiram) before planting.

5.2.2 Planting in the Aeroponic system

Seedlings are planted at 15x15 cm spacing. Hence planting holes are made accordingly and with a support of Styrofoam blocks potato seedlings are planted on the table top (Figure 33). Spraying of the liquid nutrient solution is done from the bottom using the nozzles.
5.3 Fertilizer application & Crop maintenance

A non-corrosive plastic Tank can be used for storing aeroponic nutrient solution. This tank should be cleaned well and filled with water mixed with 4ppm calcium hypochlorite 2 days before planting. On the day of planting "Albert" mixture is dissolved in water, strained and mixed thoroughly with the water in the tank. EC of the solution should be around 1500 µs (Figure 34). This level of EC can be obtained by adding 2 g of “Albert” mixture to 1 litre of water. In dry days with around 20 °C temperature, 5 seconds of spraying at 20 minutes interval is sufficient. Where as in rainy days with less light conditions spraying at 30 minutes interval is sufficient. If frequency of spraying is increased there is a risk of rotting of root system and stolon leading to death of entire crop. Therefore it is very important to manage the spraying frequency depending on the weather condition.

Plants grow well with the time. Proper pest and disease management should be adopted during the cultivation. Uninterrupted power supply is a must and a spare generator should to be readily available in case of power failures.

![Figure 34-Using EC meter to check EC value](image)

5.4 Harvesting

Four weeks after planting harvesting can be started depending on the varieties. Tubers grown to required size (Minimum 10 mm diameter) are harvested by gentle twisting of tubers from stolon (Figure 35). While harvesting sanitation should be maintained at high level and gloves should be worn by the persons harvesting. Tubers can be harvested at 3-4 days interval for 3 ½-4 months. Continuous supply of nutrient solution/ water is very important for a healthy crop (Figure36).
5.5 Hardening of Seeds

Potato tubers harvested from Aerophonic system tend to shrink as most of the time they are soaked in nutrient solution before harvesting (Figure 37). To prevent this problem hardening of these mini seed potato is necessary. This can be done in a chamber with high RH (>95%). For this seeds are spread on a net hanged above a thin water layer (Figure 38). Alternatively seed can be stored in perforated plastic trays stacked in a closed room and the floor is maintained always wet. However seeds should not directly touch with water. Seeds are allowed to harden for about 2-3 weeks and when seeds are hardened (Usually they turn into green colour) store in seed stores under optimum conditions.

6. Hydrophonic System

Potato seedlings are planted in a PVC tube containing complete nutrient solution. These tubes are filled up to 3/4th of volume. While plants are growing, stolen are prevented growing into the tube and allowed to grow into an empty chamber. Mini tubers (G₀) are harvested when they reach the right size. On an average 80-100 tubers can be harvested from one plant. This is a good method to obtain large number of high quality mini tubers preventing soil borne diseases.
6.1 Construction of the Hydrophonic system in a Polytunnel

Materials which are required to construct a Hydroponic system in a 125m² poly tunnel is given in table 01(page 20).

For a hydroponic system, table frames are constructed using either wood or iron bars, with 30 cm width, 60 cm height and with convenient length in a poly tunnel (Figure 39). These frames are fabricated 30cm above ground. Top, bottom and sides of this table frame is covered with black polythene (1000 guage). so that no light is penetrated into the free space. One side should be fixed in such a way that can be opened whenever necessary (Figure 40). White color paint can be applied on the exterior side of polythene to prevent increase in temperature around root system and stolen.

PVC tube with 12 cm diameter is fitted in the growing table, about 10cm below the top cover. Planting holes are prepared at 15 cm distance on this PVC tube. (Figure 42)

The nutrient solution tank should be placed below ground level enabling to collect the drained nutrient solution. A water pump with the capacity of 1.5 hp is used for pumping the solution. A timer is connected to the pumping unit to control the circulation interval. Nutrient solution is pumped from the tank through 32 mm diameter PVC tube up to 80cm height from the ground level and then through reduced 25mm tube. This tube is used to distribute nutrient solution in to the 12cm tube at different points.

At the far end a 110 mm diameter PVC tube is connected to the 60mm tube 2.5cm below from the top of the 110mm diameter PVC tube. This helps to maintain 3/4 of the solution level within the PVC tube (12 cm diameter) and over flowing nutrient solution is directed to water tank.
Figure. 41 - Diagrammatic illustration of Hydroponic system
6.2 Planting and maintenance of a Potato crop

6.2.1 Nursery stage

This is done same as the aerophonic system.

6.2.2 Planting in the Hydrophonic system

Planting spaces are made at 15cm x 15cm for planting the seedlings on the top of the growing table using Styrofoam. Only root system is inserted into PVC tube that contains nutrient solution (Figure 43). Shoot system of the plants remains above the top of the table which is supported by Styrofoam (Figure 44, 45, 46).

Root system must be in contact with nutrient solution right through out and stolons are allowed to grow outside the PVC tube hanging in open space. Nutrient solution should be circulated properly at regular interval of 3 hours.
6.2.3 Fertilizer application & Crop maintenance

The most important precaution in the crop management is to prevent stolon growing into PVC tube. Stolon growth and tuber formation inside the tube can block the circulation of the solution. So attention must be paid to prevent the stolon growth inside the tube. Any stolon that tends to grow into the PVC tube should be carefully removed without damaging them.

Pest and disease management in potato seed production is very important for a healthy crop. Similarly there should not be any room for light penetration into the open space where tubers are formed (Figure 45).

6.2.4 Fertilizer application & Crop maintenance

A non-corrosive plastic Tank can be used for storing nutrient solution. This tank should be cleaned well and filled with water mixed with 4ppm calcium hypochlorite 2 days before planting. On the day of planting, "Albert" mixture is dissolved in water, strained and mixed thoroughly with the water in the tank. EC of the solution should be around 1500 µs. This level of EC can be obtained by adding 2 g of “Albert” mixture to 1 litre of water.

During the whole crop duration EC value of the nutrient solution should be maintained (EC=1200 µs until 2 weeks old crop and EC=1500 µs after 2 weeks until crop maturity) at appropriate levels by adding Albert mixture and required amount of clean water.

6.3 Harvesting

Harvesting can be started four weeks after planting. It is depending on the variety (Figure 47). Tubers grown to required size (Minimum 10 mm diameter) are harvested by gentle twisting of tubers from stolen (Figure 47). While harvesting sanitation should be maintained at high level and gloves should be worn by the persons harvesting. Tubers can be harvested at 3-4 days interval for 3½-4 months. Continues supply of nutrient solution/water is very important for a healthy crop.

Figure 47- Harvesting tubers

Figure 48–Stolen with tubers

6.4 Hardening of Seeds

A special hardening process is not necessary for tubers harvested from hydroponic system as these seeds are not in direct contact with nutrient solution. Seeds are stored directly in seed stores under optimum conditions.
Annex 1

Table 1. Materials required for construction of Hydroponic/Aeroponic system in 125m² Poly tunnel

<table>
<thead>
<tr>
<th>Material required</th>
<th>Hydroponic system</th>
<th>Aeroponic system</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Black Polythene (750 gauge)</td>
<td>75 kg</td>
<td>50 kg</td>
</tr>
<tr>
<td>2. L bar (5mm, 19”)</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>3. 2 “X 2” Wire mesh</td>
<td>800m</td>
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</tr>
<tr>
<td>4. PVC (1”)</td>
<td>80X3</td>
<td>80X2</td>
</tr>
<tr>
<td>5. PVC (1/2”)</td>
<td>-</td>
<td>80x3</td>
</tr>
<tr>
<td>6. Nozzle</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>7. Down Pipe 4” (19 length)</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>8. 3/4” pipes</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>9. ½ Valve socket</td>
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<td>10. 1” Valve</td>
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<td>5</td>
</tr>
<tr>
<td>11. ¾ Valve</td>
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<tr>
<td>12. Valve Socket ¾”</td>
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</tr>
<tr>
<td>13. ¾ “Socket</td>
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</tr>
<tr>
<td>14. 2” Bend</td>
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</tr>
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<td>15. 1” Bend</td>
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<td>16. 1”-3/4” Reduction T socket</td>
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</tr>
<tr>
<td>17. ¾ “ T socket</td>
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<td>18. ¾ “Bend</td>
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<tr>
<td>19. 2” -3/4” Reduction socket</td>
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</tr>
<tr>
<td>20. 2”-1” Reduction T socket</td>
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</tr>
<tr>
<td>21. Rivet ½ “ Packs (1000/pack)</td>
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<td>5</td>
</tr>
<tr>
<td>22. Velco Tape rolls</td>
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<tr>
<td>23. Main switch</td>
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<td>24</td>
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<tr>
<td>28</td>
<td>Sun box</td>
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<td>29</td>
<td>MCB Box (double)</td>
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<td>33</td>
<td>7085 wire</td>
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<tr>
<td>34</td>
<td>1044 wire</td>
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<tr>
<td>35</td>
<td>Earth wire (50m) roll</td>
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<tr>
<td>36</td>
<td>4” End cap</td>
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<td>37</td>
<td>Nut &amp; bolt (1/2”)</td>
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<tr>
<td>38</td>
<td>L bar (3mm)</td>
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<tr>
<td>39</td>
<td>Drill bit</td>
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<td>Welding rod (Gauge 12) Box</td>
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<tr>
<td>41</td>
<td>Thinner</td>
<td>8L</td>
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<td>42</td>
<td>Enamel (4L)</td>
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