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AN AEROPONIC SYSTEM FOR THE PRODUCTION OF PRE-BASIC SEEDS OF POTATO

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ABSTRACT

Seed potato is the most expensive input in potato cultivation in Sri Lanka and therefore a basic seed potato production program was initiated by the Department of Agriculture in 1998 to increase local seed production. However, this program failed to meet all the requirements needed to increase productivity and quality of pre-basic, basic and certified seed of potato. In order to rectify this situation, a new technology, "an aeroponic system", was developed. Further, performance of this new system was compared with two other available systems, namely non-circulating solution culture and soil-less growth media. This experiment was carried out in a glasshouse at 15±5^{0}c during November 2004 to February 2005 at the Agricultural Research Station, Sita Eliya. Seedlings of the variety Desiree, raised by sand culturing of mini tubers, were transplanted at 10x10 cm distance in the growth chamber. Observations on canopy diameter, plant height, number of stolons and tubers were recorded from the 2nd to 7th week after transplanting. Maximum canopy diameter and maximum plant height were observed in the soil-less growth medium, whereas highest stolon number per plant was recorded in the aeroponic system. The most noteworthy feature was that there was a 10-fold increase in tuber production in aeroponic system over the non-circulating solution culture and soil-less growth medium.

KEYWORDS: Aeroponics, Pre-Basic Potato Seeds, Growth Medium, Hydroponics.

INTRODUCTION

At present, around 6,000 to 7,000 ha are grown under potato in Sri Lanka. The annual potato productivity during the last decade remained at an average of 12 t/ha. Non-availability of good quality disease-free seeds of desirable varieties at the correct time for planting is considered as the main constraint for increasing the productivity of potatoes in Sri Lanka. Of the annual seed potato requirement amounting to a maximum of 22,000 t, only about 3% is produced by the Department of Agriculture through tissue-culture based methods. About 5,000 t are imported by private sector organisations and the rest is produced locally by farmers themselves.

The tissue culture based pre-basic seed potato production program involves the production of *in-vitro* virus-free mother plants through meristem culture, and utilisation of these mother plants to produce rooted-stem-cuttings through a rapid multiplication process under insect-free conditions in net houses. The rooted-stem-cuttings (RSC) are grown in polytunnels to produce pre-basic seeds (G_o). These pre-basic seeds are then multiplied for three generations in the field to produce G1, G2 and G3 seeds before releasing to farmers as certified seed potato. The main constraint in this system is the low productivity (6-8 tubers/plant), incidence of soil-borne diseases such as scab and lack of suitable land for certified seed production.

Efforts were made to increase the productivity of disease-free planting material in net houses and polytunnels through improved cultural methods such as changing growth media, repeated harvest techniques *etc.*, in order to supply farms with good quality seed for further multiplication. Since these attempts were not very successful in increasing seed productivity, efforts were made to introduce suitable culture systems for mini-tuber production, such as hydroponics, as alternatives to the methods used at present.

Literature pertaining to potato cultivation in hydroponics is scarce. Hydroponics system has been used to analyze the effect of calcium deficiency on stolon apex and tuber (Li, 1985). Aeroponics is the most recent development in hydroponics methods that has gained much attention over the last decade. The first aeroponic system was developed at the University of Pia in Italy (Anon, 2002 and Harris, 1992). It is defined by International Society for Soil-less Culture as "a system where roots are continuously or discontinuously exposed to an environment saturated with fine drops (a mist) of nutrient solution". This method does not require any substrate and entails growing plants with their roots suspended in deep air in growth chambers (Harris, 1992). The main advantage of this technique is the maximum utilization of space. Scientists predict that the aeroponic systems will be rapidly adopted in the future to save energy and to increase production volume, considering increasing fuel costs for heating the greenhouses (Resh, 2001). Therefore, to cater to this problem, a new technology, "an aeroponic system", was developed and further performance of this system was evaluated along with two other available systems, namely non-circulating solution culture and soil-less growth media under local conditions for pre- basic potato production at the Agricultural Research Station, Sita Eliya.

MATERIALS AND METHODS

Three culturing systems as indicated below were tested.

1. Aeroponic system (T1)
2. Non-circulating solution-culture system(T2)
3. Soil-less growth medium (T3)

The treatments were arranged in a Completely Randomised Design with four replicates and eight plants per treatment.

T1- Areoponic system

This consisted of a 100 x 20 x 40 cm^3 growth chamber, a pump with pressure tank, a 20*l* nutrient tank, a spraying unit and a control panel with a timer (Plate 1). The growth chamber, which was made of aluminium sheets (guage 1 mm), had a removable top cover having 1-2 cm diameter holes at a spacing of 10 x 10 cm^2 to insert plants. The spraying unit was placed at the bottom of the growth chamber. The inlet of this unit was connected to the water pump through a solenoid valve and the outlet to the nutrient solution tank to collect drop-out of the solution. The nozzles of the spray unit were fixed equidistance apart to direct the nutrient solution towards the root zone at required time intervals. The timer, which was connected to the pressure switch and solenoid valve, was programmed to spray nutrients for 30 seconds at 10 minute intervals, throughout plant growth.

T2- Non-circulating solution-culture system

This system was made of an aluminium top cover measuring 30 x 45 cm^2 having 1-2 cm diameter holes at a spacing of 10 x 10 cm^2 to hold plants and a 20 *l* capacity plastic tank containing nutrient medium.

T3- Soil-less growth medium system

Plants were grown in cement blocks (measuring 40 x 30 x 30 cm^3) filled with steam-sterilised coir-dust, tea-refuse and half-burnt paddy husk (1:1:1) mixture.

Crop management

Albert's solution (Kemtek Pvt. Ltd.) at the rate of 2 kg/l of water was used as the nutrient medium for the aeroponic and non-circulating solution culture systems, whereas the recommended fertilizers were applied to the soil-less growth medium based on the surface area of plant beds. Basal dressing was applied at the time of planting and the top dressing at 2-weeks after planting.

The growth chambers were covered with black paper to cut off light and enhance tuber formation and to prevent formation of shoots from the stolons.

Evaluation

The treatment effects were estimated through the following plant growth parameters taken at weekly intervals.

1. Canopy diameter: diameter of the two-oppositely arranged largest leaves
2. Plant height from the surface of the medium to the tip of the plant
3. Number of stolons
4. Number of tubers
5. Root length

RESULTS AND DISCUSSION

Plant growth

Plants in the soil-less growth medium (T3) and the aeroponic system (T1) grew faster than those grown in the non-circulating solution-culture system (T2) (Table 1). It was evident that the aeroponics system and soil-less growth medium provided the best environment for canopy development and plant growth throughout the 7 week period after transplanting (Figures 1 & 2).

Table 1. Mean canopy diameter and plant height at 7 weeks after transplanting in different culture systems.

Culture System	*Canopy Diameter (cm)**	*Plant Height (cm)**
Aeroponic system (T1)	43.8 a	19.6 b
Non-circulating solution-culture system (T2)	9.4 b	4.6 c
Soil-less growth medium (T3)	46.7 a	25.1 a
CV (%)	9.1	15.8

*In a column, means followed by a common letter are not significantly different at p= 0.05

Stolon formation and development

In general, depending on the genotype, stolon formation in potato begins from 14 -21 days after planting (Harris, 1978). In the present study, stolon initiation was observed 14 days after planting in all culture media. Stolon formation continued up to 4th week and reached a plateau in all culture media. Stolon formation was greater in the aeroponic system (T1) as compared to the non-circulating solution-culture system (T2) and the soil-less growth medium (T3) (Figure 3).

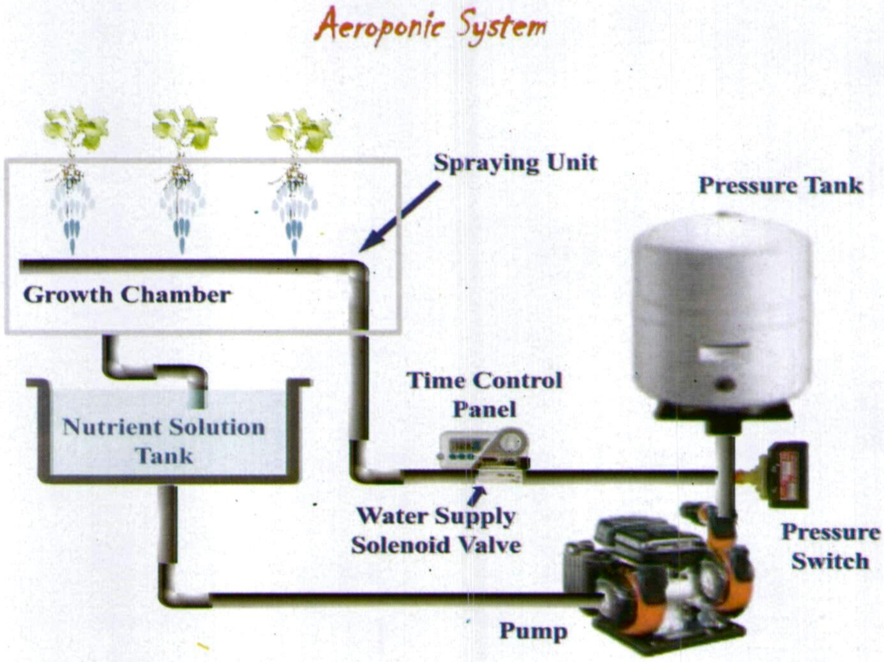
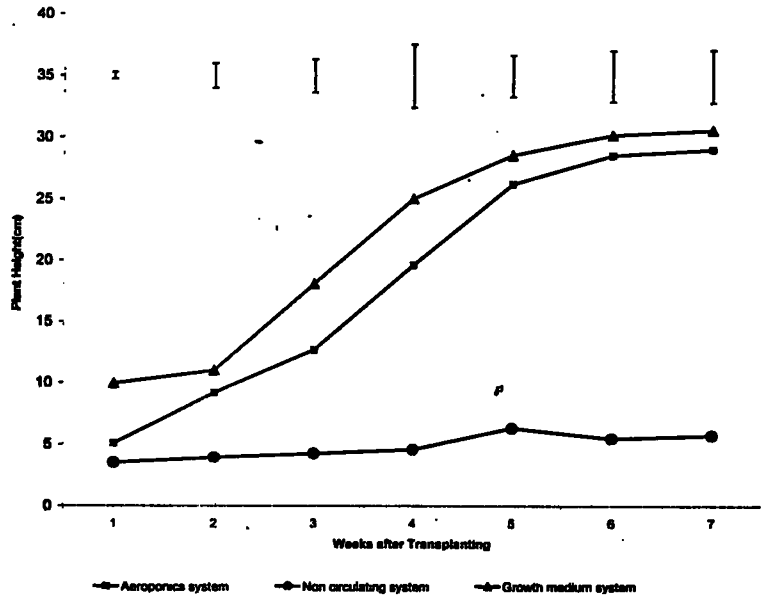
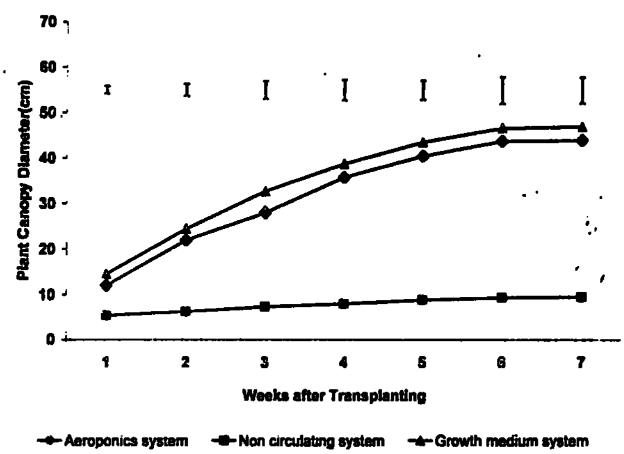


Plate 1. Aeroponic System



Vertical bars denote LSD values (P >0.05)

Figure 1. Variation of plant height at different growth stages.



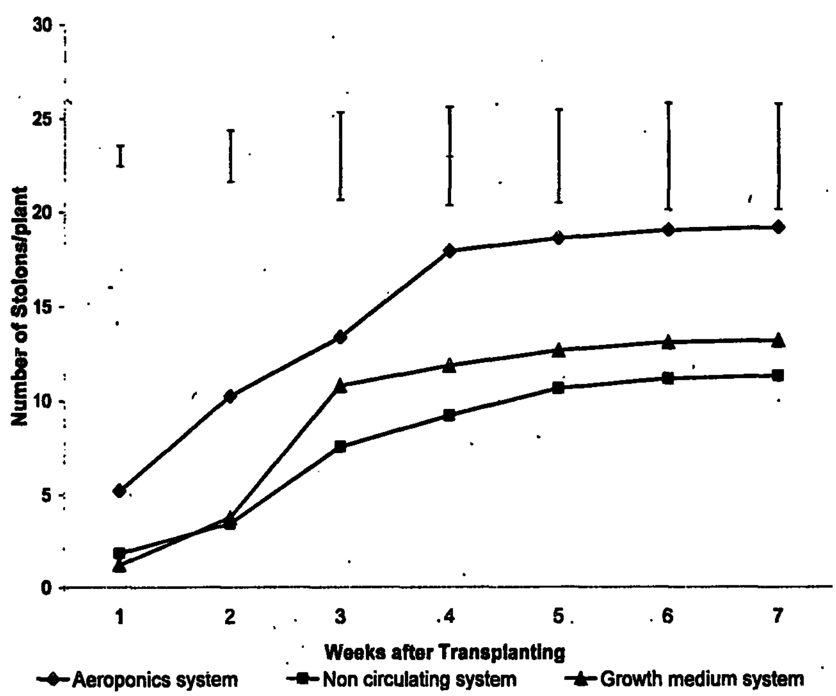
Vertical bars denote LSD values (p<0.05)

Figure 2. Variation of plant canopy diameter at different growth stages.

In the aeroponic system (T1), significantly more number of stolons were recorded at 7-weeks after transplanting than in the non-circulating solution-culture system (T2) and the soil-less growth medium (T3) (Table 2). In addition, the stolons developed in the aeroponics system produced branches. This could be due to the favourable conditions provided by the aeroponics system for the development of a long root system with numerous branches and more stolon formation and subsequent branching and production of additional mini-tubers. Many countries using aeroponic systems for mini-tuber production have reported similar results (Li, 1985; Edward, 1994; Nelson, 1998; Ross, 1998; Nichols *et al.*, 2004; Sun, 2004).

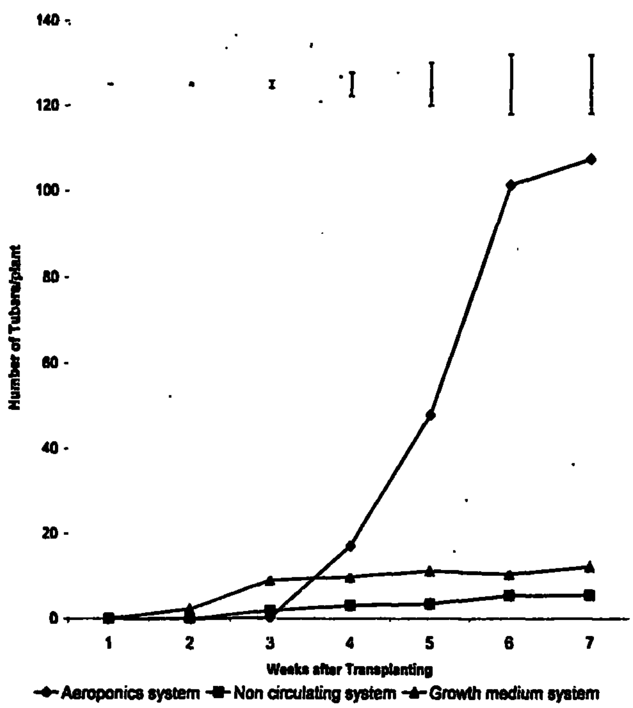
Tuber formation

In general, the tubers initiated at stolon tips in 2 weeks after transplanting and continued to bulk for three months depending on the genotype (Harris, 1982). In the present study, tuber bulking was observed only in the aeroponics system beginning at 3rd week after transplanting. The number of tubers developed in the aeroponic system (T1) was significantly higher than those produced in the non-circulating solution-culture system (T2) and a soil-less growth medium (T3) (Table 2 & Figure 4). The low productivity of stolons and tubers in the non-circulating solution-culture system (T2) and soil-less growth medium (T3) could have been attributed to the slow growth observed in those systems.



Vertical bars denote LSD values ($p<0.05$)

Figure 3. Variation of stolon number at different growth stages.



Vertical bars denote LSD values (p<0.05)

Figure 4. Variation of tuber number at different growth stages.

Table 2. Mean stolon number and tubers per plant at 7 weeks after transplanting in different culture systems.

Culture System	*Stolons / Plant*	*Tubers / Plant*
Aeroponic system (T1)	17.9 a	101.3 a
Non-circulating solution-culture system (T2)	9.2 b	5.4 b
Soil-less growth medium (T3)	11.9 b	11.9 b
CV (%)	15.8	20.5

In a column, means followed by a common letter are not significantly different at p= 0.05

Plants in aeroponic system also showed secondary growth of solons. In this system, removal of tubers by repeated harvesting contributed to increase in tuber formation. Struik and Wiersema, (1999) reported that repeated harvesting helped break apical dormancy and hence increasing the yield. Tuber productivity in the aeroponic system in the present study averaged around 101 tubers/plant. These figures are comparable to those recorded in other countries (Waterhouse, 1999). Furthermore, this is a 10-20 fold increase of tuber productivity recorded in Sri Lanka when compared with other systems used so far. This system also provides greater opportunities to produce disease-free tubers. However, the cost effectiveness is yet to be evaluated for commercial scale implementation.

CONCLUSIONS

It can be concluded that of the various systems adopted for the production of pre- basic seeds of potato in the present study, the aeroponic system appeared to be the best. This system gave a ten-fold increase in tuber production over the other systems currently adopted. Steps will be taken to obtain patent rights to this new system designed by the Department of Agriculture.

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