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Production of *Solanum tuberosum* L. Microtuber Using Temporary Immersion System

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Abstract

Background: Potato (*Solanum tuberosum* L.) is an annual crop which belongs to the Solanaceae family of flowering plants and is native to South America. Potato is the fourth most important food crop worldwide, planted on 20 million ha globally in 2005. The need for a sustainable potato production depends on a constantly renewed supply of disease free planting material. Tissue culture micropropagation was used to revolutionize the potato industry in the 1970's and with this technique disease-free plantlets were used to produce healthy seed tubers for farmers. This study compared the yield and nutrient profile of Spunta 58 70 77 minitubers produced by TIS with Shepody minitubers grown by local farmers.

Methodology: *In vitro* tissue culture plantlets received from the Scientific Research Council's genebank were grown in a TIS containing Murashige and Skoog (MS) multiplication media for three weeks at 25 ± 2°C with 16-h photoperiod under fluorescent light with a photon flux of ~52 µmol $m^{-2}s^{-1}$. After three weeks the medium was replaced with a tuber MS induction medium for six weeks in dark conditions at 25 ± 2°C. Immediately following induction, microtubers were allowed to sprout for twelve weeks in the dark at 25 ± 2°C. Traditionally grown (TG) and TIS microtubers with at least one shoot (>1 in) were then transferred to field in a randomized complete block design. After 12 weeks the physical and nutrient profiles were determined and compared.

Results and Discussion: Minitubers produced by TIS had fresh weight (19.8 ± 2.1 g), length (8.1 ± 0.5 cm) and diameter (5.3 ± 0.3 cm) that were not significantly different ($p \geq 0.05$) from TG minitubers with fresh weight (38.6 ± 3.7 g), length (9.4 ± 0.5 cm) and diameter (5.8 ± 0.3 cm). Similarly, the nutrient profiles of tissue culture and traditionally grown microtubers were not significantly different ($p \geq 0.05$). However there was a significantly higher iron content (6.21 ± 1.04 mg/kg) in TG minituber when compared to TIS (2.01 ± 1.1 mg/kg). Temporary immersion system may be a valuable alternative for potato microtuber production. This technique could be used to increase the local production of generation one Irish potato thereby providing high quality seed potato to meet the national demand.

Keywords: Minituber; Potato; Temporary immersion system

Introduction

Potato (*Solanum tuberosum* L.) is an annual crop which belongs to the Solanaceae family of flowering plants and is native to South America. Over a billion people worldwide eat potato and global crop production exceeds 300 million metric tonnes. Potato is food for both humans and animals; it also serves as raw material for the food processing (e.g., potato chips, french fries, and dried potatoes) and starch industries [1]. The commercial advantages of the potato are its high yield potential in a short growth time, high edible dry matter content of the tubers, and high dietary value as a staple food.

The Food and Agriculture Organization of the United Nations affirms that potatoes are susceptible to a variety of diseases that reduces yield and tuber quality. Therefore the potato industry requires a sustainable production system that generates a constant supply of disease free planting material. Tissue culture micropropagation was used to revolutionize the potato industry in the 1970's and with this technique disease-free plantlets were used to produce healthy seed tubers for farmers. However, this method is time consuming and requires acclimatization of plantlets before mini-tuber production [2]. A temporary immersion system (T.I.S) provide several advantages over in vitro micropropagated plants due to the fact that the tubers can be stored and transplanted directly into the field without an acclimatization stage. The T.I.S provides a sterile environment that relies on liquid nutrient/air influx and out-flux in vessels made of glass or plastic. This system is designed to rapidly scale up the production of tissue culture planting material with the ability to regulate the micro environmental conditions [3].

According to the Ministry of Industry, Commerce, Agriculture & Fisheries of Jamaica, an Irish Potato Programme was implemented in 2013- 2014 to boost production of Irish potato by meeting the national demand of 15 million kilograms. This food crop is economically important to our country and by

depending solely by traditional methods this demand will not be satisfied due to the challenges faced by crop pest and diseases. This study was designed to assess the yield and nutrient profile of Spunta 58 70 77 minitubers produced by temporary immersion system and traditional propagated Shepody minitubers [4].

Materials and Methods

The research was conducted at the Biotechnology laboratory of the Product Research and Development Division at the Scientific Research Council, Jamaica.

Two Irish potato cultivars were used in this study. Spunta 58 70 77 cultivar was obtained from the Scientific Research Council's genebank and Shepody obtained from a local farmer [5].

Tissue culture Spunta 58 70 77 plantlets received from the Scientific Research Council's genebank were grown in a TIS containing Murashige and Skoog (MS) multiplication media (Murashige & Skoog, 1962) for three weeks at 25 ± 2°C with 16-h photoperiod under fluorescent light with a photon flux of ~52 µmol $m^{-2}s^{-1}$. This multiplication medium was prepared using MS medium, thiamine HCL (0.5 mgL^{-1}), myo inositol (100 mgL^{-1}) and 2% sucrose. After three weeks the medium was replaced with a tuber MS induction medium for six weeks in dark conditions at 25 ± 2°C. The induction medium consisted of MS medium, thiamine HCL (0.5 mgL^{-1}), myo inositol (100 mgL^{-1}) and 8% sucrose. After induction, microtubers were allowed to sprout for 12 weeks in the dark at 25 ± 2°C and then transferred to soil in a shadehouse for 12 weeks. TIS minitubers were then harvested and allowed to sprout for an additional 12 weeks. Traditionally grown (TG) Shepody and TIS Spunta 58 70 77 minitubers with at least one shoot (>2.5 cm) were then transferred to field in a randomized complete block design [6,7]. After 12 weeks the fresh weight (g), length (cm) and diameter (cm) were determined and compared. Moisture content, protein, sodium, calcium and iron were also determined according to the procedure described by the AOAC (1993), potassium and sodium by Williams et al. (1962), vitamin C by Schroeder et al. (1950) and carbohydrates by difference.

Statistical analysis was performed using statistical package SPSS version 19.0 (SPSS, Cary, NC, USA). Comparison between TIS and TG minitubers was done by the independent sample t-test. A value of $p \leq 0.05$ was considered significant. Data are reported as mean ± standard error (SE) [8].

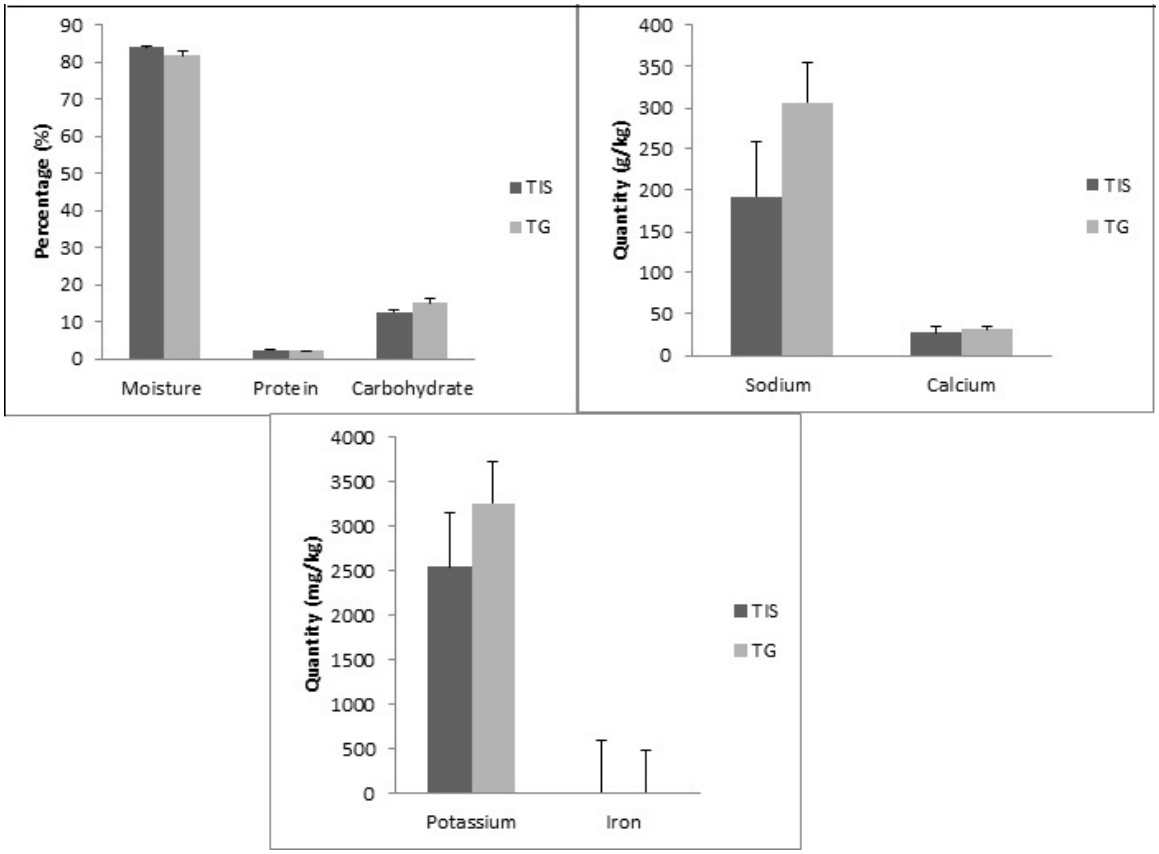

Figure 1: Nutrient profile of tissue cultured microtubers (TIS) and traditionally grown microtubers (TG).

Results and Discussion

Potato is among the top four staple food crop grown worldwide. It is also used as a raw material for the food processing and starch industries in Jamaica and other territories. According to the Ministry of Agriculture of Jamaica (MOA), the total consumption of Irish potato in 2008 was 12,454 tonnes. However, local production only contributed to 39.6% of this

demand and the rest imported [9]. Therefore the MOA in 2013 saw the need to establish an Irish potato programme that will boost production to meet the national demand of 15,000 tonnes by 2015. This target was achieved in 2011 with the intervention of tissue culture techniques, such as TIS and other management strategies. The use of traditional propagation methods only was not lucrative due to the challenges of crop diseases and the availability of minitubers during the period of November to March each year [10]. Therefore, using microtubers generated from tissue culture technologies is important in ensuring that affordable pathogen-free minitubers are available to farmers throughout the year. This study compared the yield and nutrient profile of Spunta 58 70 77 minitubers produced by TIS with Shepody minitubers grown by local farmers.

Table 1 and **Figure 1** indicate that the tissue cultured minitubers had similar physical properties when compared to those grown by traditional practice. Minitubers produced by TIS had fresh weight (19.8 ± 2.1 g), length (8.1 ± 0.5 cm) and diameter (5.3 ± 0.3 cm) that were not significantly different ($p \geq 0.05$) from TG minitubers with fresh weight (38.6 ± 3.7 g), length (9.4 ± 0.5 cm) and diameter (5.8 ± 0.3 cm). Similar results were obtained by researchers Oggema et al. (2007), when investigating the agronomic performance of traditionally grown and tissue culture regenerated sweet potatoes. They reported no significant difference in yield between the plants studied.

Table 1: The Mean Weight, Length and Diameter for Tissue Culture Minitubers (TIS) and Traditionally Grown Microtubers (TG).

	Weight (g)	Length (cm)	Diameter (cm)
TIS	19.8 ± 2.1	8.1 ± 0.5	5.3 ± 0.3
TG	38.6 ± 3.7	9.4 ± 0.5	5.8 ± 0.3

Subscripts with different letters denotes significant differences ($p<0.05$). Values are mean ± standard error for (TIS) n=147 and (TG) n=12

Similarly, the nutrient profiles of TIS and TG minitubers were not significantly different ($p \geq 0.05$). However, significantly higher iron content (6.21 ± 1.04 mg/kg) was observed in TG minituber when compared to TIS (2.01 ± 1.1 mg/kg), this difference may be due to variation between the cultivars [11].

The results of this study suggest that TIS could be a suitable technology to generate pathogen-free minitubers that meet farmers' expectations. The yield and nutritional profiles are similar to that of traditionally grown minitubers and therefore may used to increase availability of planting material throughout the year [12,13]. This may prove beneficial to the agro-industry as availability of second generation minitubers has shown to be a major factor impacting positively on the Irish potato production and by extension satisfying the local market demand.

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