Performance of Two Potato Cultivars Derived from In-vitro Plantlets, Minitubers and Stem Cuttings Using Aeroponics Technique

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Abstract
An experiment was conducted at KALRO-Tigoni to assess the effect of starter plant material (in-vitro plantlets, stem cuttings and minitubers) on minituber production of two potato cultivars Asante and Tigoni under aeroponic conditions. The experiment was set up in the aeroponic unit at KALRO-Tigoni in randomized complete block design (RCBD) replicated three times. Data were collected at each harvest on the number of minitubers produced per plant; the minitubers were later graded into three weights (0.1-5g, 5.1-12g, >12g). Cultivar Tigoni produced a higher total number of minitubers (49.96) and (52.67) compared to Asante which produced (39.63) and (46.39) minitubers in season one and two respectively. Additionally, in-vitro propagation materials gave the highest number of minitubers (56.44 and 62.94) compared to stem cuttings (43.53 and 51.44) and minitubers (34.42 and 34.19) during the two seasons respectively. The results of this study suggest that the starter materials have a significant effect on the number of potato minitubers produced under the aeroponic system regardless of the potato cultivar. Use of in-vitro plantlets as starter material optimizes minituber production in the aeroponic system. However, the study should be repeated so as to come up with concrete results.

Keywords Aeroponics Asante; Potato minitubers; Starter material; Tigoni

1 Background

In Kenya potato (Solanum tuberosum L.) is the second most important staple crop after maize and plays a major role in national food and nutritional security (Janssen et al., 2013). Potato is grown by about 800,000 farmers cultivating about 161, 000 hectares per season with an annual production of about 3 million tonnes in two growing seasons (GTZ-PSDA, 2011; MoALF, 2016). The annual potato crop is valued at KSh. 50 billion (USD 500 million) at farm gate prices (GTZ-PSDA, 2011; MoALF, 2016). Beyond the farm, the industry employs about 3.3 million people as market agents, transporters, processors, vendors and exporters (ANN, 2009; MoALF, 2016). In addition potato is a vital source of calories, proteins, vitamins, potassium and fiber. Most potato producers are small scale farmers; it is estimated that 90% of them own less than 1 ha (Janssen et al., 2013). Most of these farmers depend on rainfall to produce their crops. Yields are low [4.4 to 10 t ha-1 with an average of 7.7 t ha-1 (MoA, 2008; Muthoni et al., 2010; Janssen et al., 2013)]. Low yields are mainly due to use of poor quality seed potato, low soil fertility, low and erratic rainfall, pests and diseases (Janssen et al., 2013). Certified seed potato is expensive (about US$ 30 for a 50 kg bag) yet one requires 16 such bags to plant one acre. In addition, certified seeds are scarce; certified seed potato producers supply less than 5% of the national demand. Consequently, most farmers plant seed tubers from informal sources such as own harvests, neighbours and local markets with own harvests being the major source of seed for most farmers. Continuous cultivation of these farm-saved seeds encourages build up of diseases such as bacterial wilt and viruses.

Production of disease-free potato seed tubers starts with tissue culture using meristem tip culture (KARI, 2007). The in-vitro plantlets produced are then multiplied 3 to 4 times in the laboratory using nodal cuttings. Later, they are transferred into seedling trays containing sand substrate for hardening and further growth. They are then transplanted into the aeroponic boxes or soil-filled pots for production of minitubers (generation 0) (Muthoni et al.,
2011). The minitubers are then multiplied in the field for three generations to produce basic seeds. The three generations (1, 2 and 3) are meant to increase the amount and size of seeds. The basic seeds are distributed to certified seed producers who produce certified seeds; the certified seeds are then sold to farmers for production of ware potatoes (KARI, 2007). At KALRO-Tigoni, there is low efficiency in basic seed potato production. This is mainly because minitubers are produced using the soil-filled pots; the technique has a low multiplication rate (6 to 8 tubers /plant) unlike aeroponics which can give 50 to 100 tubers per plant (Otazu, 2010; Muthoni et al., 2011). To counter this problem, an aeroponic unit was set up at KALRO-Tigoni in 2008 by the international potato centre (CIP) to enhance minituber production.

In addition to in vitro plantlets, minitubers can also be produced from stem cuttings as well as from minitubers. Stem cuttings can be made on plantlets in the seedling trays so as to increase the number of plants without incurring tissue culture costs. Stem cutting propagation is among the most productive and highly efficient low cost potato multiplication procedures. Using stem cuttings, a single plantlet can yield up to 100,000 progenies in 6 months (Ngaruiya et al., 2013).

In light of foregoing, a study was carried out to assess minituber production from three different starter planting materials (in-vitro, mini-tubers and stem cutting) of two potato varieties under aeroponic conditions.

2 Materials and Methods

The experiment was conducted for two successive growing periods (season one: July to December 2010 and season two: January to May 2011) at KALRO-Tigoni. The experiment was set up as a factorial arrangement in a randomized complete block design (RCBD) with three replications. Factor one was the starter material i.e. in-vitro plantlets, mini-tubers and stem cutting) while factor two was the potato cultivar i.e. Asante and Tigoni. Each aeroponic growth chamber represented a replicate consisting of six treatments combinations. Each treatment consisted of thirty transplants at a spacing of 20 cm x 20 cm.

Plantlets originating from tissue culture (in vitro plantlets), stem cuttings and minitubers were planted in the aeroponic growth chamber. Each sub-plot consisted of 30 transplants at a spacing of 20 cm x 20 cm.

2.1 Preparation of planting materials

1. In-vitro plantlets: Nodal cuttings (one cm) of the two cultivars (Tigoni and Asante) were cut from preceding generation of in-vitro plantlets and cultured in Kilner jars containing 100ml Murashige and Skoog (1962) media supplemented with glycine 0. 2 g/L, nicotinic acid 0.05 g/L, pyridoxine 0.05 g/L, inositol 10 g/L thiamine 0.01 g/L, gibberellic acid 0.001 g/L, and sucrose 30 g/L. The cultures were then incubated for three weeks in the growth room maintained at 20 ± 2°C and a 16-hr photoperiod having light intensity of 3,000 lux. The plantlets were then transplanted into crates filled with steam-sterilized sand under greenhouse conditions for two weeks.

2. Stem cuttings: In-vitro plantlets of the two potato cultivars (Tigoni and Asante) were raised in crates filled with steam-sterilized sand for 10 days in a greenhouse. The growing points were nipped to allow the development of lateral shoots. When the lateral shoots attained a length of 6-10 cm, they were cut (using a sterile surgical blade). The cut ends were dipped into a rooting hormone (Roothom H (0.6%) Indolebutyric acid) and then planted in crates filled with steam sterilized sand for two weeks.

3. Minitubers: Minitubers (3 g each) harvested from soil-filled pots were sown in crates filled with steam-sterilized sand at a depth of two cm. The crates were kept in a greenhouse for two weeks.

Nutrient solution containing 2.2 gms KNO3, 1.4 gms NH4NO3, 0.8 gms Ca superphosphate, 0.8 gms MgSO4, 0.036 gms Fe(EDTA) 6% and 0.048 gms Micro (Fetrilon) at a pH of 6.5 was applied to the plants for the duration they were in the crates. The plants were then transplanted into the aeroponic boxes after attaining a height of 10-15 cm.
2.2 Aeroponic growth chamber

Three aeroponic growth chambers each measuring 600 cm long x 130 cm wide x 85 cm deep were used. Each chamber accommodated 180 plants at a spacing of 20 cm and represented a single replicate. The growth chambers were setup inside a screen house measuring 30 m x 6 m and the roof was made of clear asbestos sheets covered with a shade net on top to regulate the amount of sunlight entering and to lower the temperatures.

2.3 Data collection and analysis

Fifty two days after transplanting starter plant materials in the growth chambers, the first batch of minitubers were harvested, subsequent harvests were done at 14 days interval and continued until 180 days after transplanting making a total of 10 harvests. At each harvest, data were taken from the six middle plants in each treatment. The minitubers were sorted and graded into three weights (0-5 g, 6-12 g, >12 g). Data from all the 10 harvests were averaged before analysis. Data on the numbers of minitubers were subjected to the analysis of variance (ANOVA) using Genstat statistical package 14th edition (Payne et al., 2011). Comparisons between treatments were made using Fisher’s protected Least Significant Difference (LSD) at 5 % level of significance.

3 Results

In each season, interaction between the starter materials and cultivars were not significant (P≤0.05), therefore cultivars and starter materials main effects were discussed separately. Generally, cultivar Tigoni produced significantly (P≤0.05) more minitubers than Asante in both seasons (Table 1), the difference was more pronounced among the small-sized tubers.

Table 1 The mean number of minitubers per plant for potato cultivars Tigoni and Asante

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Season one</th>
<th></th>
<th></th>
<th></th>
<th>Season Two</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asante</td>
<td>Weight I</td>
<td>Weight II</td>
<td>Weight III</td>
<td>Total</td>
<td>Weight I</td>
<td>Weight II</td>
<td>Weight III</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>23.30a</td>
<td>11.50a</td>
<td>5.39a</td>
<td>39.63a</td>
<td>29.56a</td>
<td>11.93a</td>
<td>4.91a</td>
<td>46.39a</td>
</tr>
<tr>
<td>Tigoni</td>
<td>30.70b</td>
<td>13.07a</td>
<td>6.19a</td>
<td>49.96b</td>
<td>35.56b</td>
<td>10.80a</td>
<td>6.31b</td>
<td>52.67b</td>
</tr>
<tr>
<td>Means</td>
<td>27.00</td>
<td>12.29</td>
<td>5.79</td>
<td>44.80</td>
<td>32.56</td>
<td>11.36</td>
<td>5.61</td>
<td>49.39</td>
</tr>
<tr>
<td>C.V</td>
<td>19.2</td>
<td>28.9</td>
<td>59.0</td>
<td>13.7</td>
<td>26.6</td>
<td>40.5</td>
<td>50.5</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Note: Minutiber weight (g): weight I = 0.1-5 g, weight II = 5.1-12 g, weight III = 12 g<. Within a column, numbers followed by different letters are significantly different at P≤0.05.

The three starter materials differed significantly (P≤0.05) in their effect on the number of minitubers produced under aeroponic conditions (Table 2). Among the three starter materials evaluated, in-vitro plantlets produced the highest total number of minitubers per plant for all weights in both seasons (Table 2).

Table 2 The mean number of minitubers for the three starter materials (in vitro plantlets, stem cuttings and minitubers)

| Starter materials | Season One | | | | | | | | Season Two | | | | | | |
|------------------|------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| In-vitro         | Weight I   | Weight II | Weight III | Total           | Weight I   | Weight II | Weight III | Total           |
|                  | 37.86c     | 16.83b    | 12.58c     | 66.44c           | 43.36c     | 12.39b    | 7.19b      | 62.49c           |
| Stem cuttings    | 24.06b     | 12.86a    | 6.16b      | 43.53b           | 33.47b     | 11.22ab   | 6.75b      | 51.44b           |
| minitubers       | 19.08a     | 11.42a    | 3.92a      | 34.42a           | 20.83a     | 10.47a    | 2.89a      | 34.19a           |
| Means            | 27.00      | 12.29     | 5.79       | 44.80           | 32.52      | 11.36     | 5.61       | 49.53           |
| L.S.D.           | 3.364      | 2.324     | 1.367      | 5.805            | 2.916      | 1.534     | 1.547      | 4.487            |
| C.V              | 26.6       | 40.5      | 50.5       | 18.2            | 19.2       | 28.9      | 59.0       | 13.7            |

Note: Minutiber weight (g): weight I = 0.1-5 g, weight II = 5.1-12 g, weight III = 12 g<. Within a column, numbers followed by different letters are significantly different at P≤0.05.

4 Discussion Conclusion and Recommendation

From the results Tigoni produced more minitubers per plant than cultivar Asante. This could have been due to a longer growing period of Tigoni compared to Asante under aeroponic conditions. Tigoni is late maturing while Asante is early maturing. Generally, there were more small-sized minitubers than larger ones (Table 1 and Table...
2). This could have been due to the short harvesting interval; maybe a longer interval would have yielded different results. Use of In-vitro plantlets as starter material resulted in production of more minitubers per plant than use of minitubers or stem cuttings. This result corroborates with the findings of Bandoni and Chauhan (2010). The results of this study support the view that in-vitro plantlet starter materials are appropriate for optimizing minituber production under aeroponic conditions. However, the experiment needs to be repeated especially with different potato cultivars so as to come up with useful recommendations.

Acknowledgements

The authors acknowledge and express their gratitude to the former Centre Director, KARI Tigoni for funding and allowing the undertaking of this experiment.

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https://doi.org/10.1007/BF02869609
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