Effects of pit, dark and cold pre-storage treatments and their duration on dormancy breaking and sprouting of seed potato tubers (*Solanum tuberosum* L.)

Mwalimu K. Menza¹#, Solomon I. Shibairo², Richard O. Nyankanga², Paul Demo³, Jackson N. Kabira⁴, and Peter Gildemacher³.

¹Kenya Agricultural Research Institute, National Horticultural Research Center, P.O. Box 220, 01000, Thika, Kenya
²Plant Science and Crop Protection Department, University of Nairobi, P.O. Box 29053, 00625, Kangemi, Nairobi, Kenya
³International Potato Centre, Sub-Sahara Region, P.O. Box 25171, 00603, Nairobi, Kenya
⁴Kenya Agricultural Research Institute, National Potato Research Center, P.O. Box 338, 00217, Limuru, Kenya

#Corresponding author; Tel = +254-020-55038, Cell phone = +254-0723623309, email = mwalimu81@yahoo.com or karithika@africaonline.co.ke
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Abstract

Potato is the second most important food crop after maize in Kenya. In the traditional areas of potato production with a bimodal rainfall pattern in the country, poor sprouting, due to seed tuber dormancy, is a major drawback. There is little time between growing seasons to permit adequate sprouting of the seed tubers. Therefore, effects of pit, dark and cold pre-storage treatments and their duration on dormancy breaking and sprouting of seed potato tubers of variety Asante were determined. Tubers were evaluated for sprouting, number of sprouts per tuber and sprout vigor for 12 weeks. Pit and dark pre-storage treatments resulted in significantly higher sprouting, number of sprouts per tuber and vigor scores than cold pre-storage treatment and the control (diffused light storage). 100% sprouting of seed potato tubers was attained under pit storage by the fourth week for all pre-storage treatment durations while dormancy ended after 6 weeks of storage in the control. Sprouting was suppressed during cold pre-storage treatment. In pit and dark pre-storage treatments, vigor scores increased with increasing duration of pre-storage treatment while in the cold, vigor scores were reduced with longer pre-storage treatment duration. Pit and dark pre-storage treatments for short durations of up to one week respectively followed by two weeks of diffused light storage are recommended to break dormancy and promote sprouting of good quality seed potato tubers of Asante variety.

Key words: dormancy, potato, seed tuber, sprouting.

Introduction

Potato is the second most important food crop after maize in Kenya (Guyton *et al.*, 1994; MoA/GTZ, 1998). In the traditional areas of potato production with a bimodal rainfall pattern in the country, poor sprouting, due to seed tuber dormancy, is a major drawback. There is little time between growing seasons to permit adequate sprouting of the tubers. Limited supply of good quality seed tubers and high costs are major constraints to potato production in many developing areas like Kenya (Crissman *et al.*, 1993; Maingi *et al.*, 1994). Many farmers therefore use low
quality seed recycled over many generations leading to low yields (Maingi et al., 1994). Natural
diffused light increases sprout number in seed tubers, reduces total storage losses, and has been
shown to increase yields due to improved seed vigor (CIP, 1984). However, diffused light
storage delays sprouting by more than four weeks in some genotypes (Demo et al., 2004).

Resource poor farmers promote potato sprouting by placing tubers in pits lined with dry leaves
and covered with straw (MoA and GTZ, 1998). Tubers sprouted in pits are, however, of poor
quality due to apical dominance and shoot etiolation caused by the dark conditions. Storing
tubers in dark conditions results in production of extensively long etiolated sprouts as opposed to
dark green leaves and expansive plant from tubers exposed to light (Crissman et al., 1993).
Therefore there is need to improve the quality of seed potato tubers sprouted under pit and dark
conditions. Cold temperatures are considered to be stressful to the tuber and can hasten sprouting
(Burton et al., 1992). Seed potato tubers can be held at 4°C to beyond the end of natural
dormancy and then stored in light at about 15°C to provide multigreen sprouting (Burton, 1989).

The objective of the study therefore was to determine the effects of pit, dark and cold pre-storage
treatment and their duration on dormancy breaking and sprouting quality of seed potato tubers.

Materials and methods
Potato variety Asante was grown between October 2005 and February 2006 (season 1) and in
April 2006 to July in 2006 (season 2) at the National Potato Research Centre (NPRC) – Tigoni
Kenya. Tigoni lies at an altitude of 2,100 m above sea level with a mean annual rainfall of 800
mm and an evaporation rate of 180 mm p.a. Tubers were planted in furrows at the recommended
spacing of 0.75 x 0.30 m in 30 x 30 m plots. Ridging, pest and disease control, fertilization and
weeding were done under recommended practices. The crop was dehaulmed two weeks prior to harvesting. The potatoes were harvested 104 days after planting in seasons 1 and 2 respectively. Freshly harvested tubers were sorted and cured under diffused light storage conditions for 1 week. Medium sized undamaged seeds of 35 - 45 mm diameter were used for the trial.

The pit pre-storage treatment involved digging 4 replicates of pits of 0.6 m length by 0.6 m width by 0.6 m depth. A 10 cm layer of dry maize stovers was then put at the bottom of the pit. Seed tubers were put in 0.5 by 0.4 m nylon woven mesh bags. The bags with potatoes were then placed in the pit and covered with a layer of dry maize stovers. A thin layer of soil was put on top of the stovers to cover the pit. The dark pre-storage treatment involved placing seed potato tubers in a totally dark room. Tubers were put in 0.5 by 0.4 m nylon woven mesh bags. The bags were put in sisal gunny bags of 0.8 m length by 0.6 m width and placed on wooden benches in the dark room. Cold pre-storage treatment was achieved by placing seed potato tubers in a cold room at a constant temperature of 4°C. Tubers were put in 0.5 by 0.4 m nylon woven mesh bags. The bags were then put in the cold room. Control pre-storage treatment involved putting seed potato tubers in 0.3 by 0.3 m paper trays and placing them in diffused light storage (DLS) for 12 weeks. Seed potato tubers under the pre-storage treatments of pit, dark and cold were removed after a duration of 1, 2, 3 and 4 weeks for further storage under DLS. The tubers were put in 0.3 by 0.3 m paper trays. The trays with seed potato tubers were then placed on wooden shelves and held in the DLS store. The experimental design comprised of 4 x 4 factorial combinations of treatments laid out in a completely randomized design (CRD) replicated four times involving 20 tubers per replicate in each pre-storage treatment and pre-storage treatment duration. Tubers were evaluated upon removal at each duration and thereafter at week 4, 6, 8, 10 and 12 for sprouting, number of sprouts per tuber and vigor.
A tuber was considered sprouted when it had at least one visible sprout of at least 2mm length (Van Ittersum, 1992). Sprouting was calculated as a percentage of the number of sprouted tubers in the sample. End of dormancy was defined as the period when 80% of the tubers had sprouted (Wiersema, 1985). Vigor score was evaluated based on the thickness of the base of the sprout and the sprout length. The evaluation was based on a five-point rating scale where 1 = very low vigor 2 = low vigor, 3 = good vigor, 4 = high vigor and 5 = very high vigor (Shibairo et al., 2006).

**Statistical analysis**

Data were analyzed using Genstat statistical program (Genstat, 1995). Mean differences between treatments were determined by Fisher’s least significant difference test at 5% level of significance (Steel and Torrie, 1987).

**Results**

**Sprouting**

Tuber sprouting differed significantly ($P \leq 0.05$) with pre-storage treatment and pre-storage treatment duration in both seasons (table 1). Seed potato tubers in the dark and pit pre-storage treatments had significantly higher sprouting than cold pre-storage treatment and the control. Dormancy ended within three and four weeks of pit and dark pre-storage treatments respectively. Removal of tubers after pre-storage treatment of one week caused dormancy to break in 2 weeks of subsequent diffused light storage in both pit and dark pre-storage treatments.
**Number of sprouts per tuber**

Number of sprouts per tuber differed significantly ($p \leq 0.05$) among pre-storage treatments and pre-storage treatment durations in both seasons (table 1). Pit pre-storage treatment gave significantly higher number of sprouts per tuber followed by dark, cold and control treatments in a decreasing order. In all treatments, the number of sprouts per tuber increased with increasing time of diffused light storage.

**Vigor of sprouts**

There were significant differences ($P \leq 0.05$) among pre-storage treatments and treatment durations in vigor score in both seasons (table 1). The lowest vigor scores were observed in tubers under cold storage followed by diffused light storage, dark storage and pit storage in an increasing order. In all treatments, the sprout vigor increased with increasing time of diffused light storage.

**Discussion and conclusion**

Faster dormancy breaking and promotion of sprouting in potato tubers under dark and pit conditions has been reported previously (Hunt, 1982; Bencini, 1991; MoA and GTZ, 1998; Shibairo *et al.*, 2006). In this study, dormancy ended in three and four weeks of pit and dark storage respectively while removal of the tubers after one week caused dormancy release in two weeks of subsequent diffused light storage (DLS) in both methods. High temperatures and low light intensities are known to promote sprout growth. In season 1, pit temperature rose to $22 \pm 4 ^\circ{C}$ compared to $15.1 ^\circ{C}$ in DLS while in season 2 the pit temperature rose to $23 \pm 5 ^\circ{C}$ compared to $15.3 ^\circ{C}$ in DLS. Earlier findings point out that dormancy in potato tubers is shortened by higher relative humidity (RH) (Burton, 1989; Beukema and Van der Zaag, 1990). Increased
carbon dioxide (CO₂) concentrations under pit conditions have also been associated with faster dormancy break in potato tubers (FAO, 1989). The high RH, high CO₂ levels coupled with a rise in temperatures are likely to have hastened dormancy termination and sprouting in the pit.

The pit pre-storage treatment gave the highest number of sprouts per tuber followed by dark, cold and control pre-storage treatments in a decreasing order. Rhoaeds et al., (1983); suggested that higher number of sprouts per tuber lead to increased potato yields. Results of this study contradict the findings of other workers (e.g. Gildemacher et al., 2007), who indicated that seed potato tubers which have been forced to sprout using farmers’ methods such as pit and dark storage are prone to single sprouts. In this study, number of sprouts per tuber was increased under pit and dark pre-storage treatments. This shows that relatively shorter pre-storage treatment durations of up to two weeks in pit and dark followed by exposure to DLS may result in higher number of sprouts per tuber and therefore minimising problems associated with sprouting seed potato tubers under dark conditions.

Storage of seed potato tubers under dark conditions leads to weak and poor vigor sprouts (Crissman et al., 1993; CIP, 1984). However, results of this work have shown that increase in dark pre-storage treatment duration followed with storage under DLS led to increase in vigor. This suggests that the quality of dark pre-sprouted seed potato tubers can be improved if it is followed by DLS storage. Results of this work also showed that a longer cold pre-storage treatment of tubers led to reduced vigor scores. Pit and dark pre-storage treatments reduced dormancy period to three weeks and increased sprouting, number of sprouts per tuber and vigor score. Therefore the two pre-storage treatments are recommended for breaking dormancy and promoting sprouting of seed potato tubers of Asante variety. Short pre-storage treatment
durations of up to one week in the pit and dark respectively, followed by two weeks of storage in diffused light is suggested. The pit and dark pre-storage treatments offer a reliable approach for the supply of good quality seed for both the formal and informal seed systems. Further research is recommended on field performance of potato from seed tubers subjected to the various pre-storage treatments. Studies involving larger seed potato tuber quantities and more varieties are also suggested.

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References


M. K., Menza et al., 2008. Dormancy breaking and sprouting of seed potato tubers


MoA (Ministry of Agriculture), Kenya and GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit), (1998). Post-harvest systems of potato and sweet potato in Kenya - Final report Ministry of Agriculture and Deutsche Gesellschaft für Technische Zusammenarbeit GmbH NAIROBI


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Table 1. Effects of pit, dark and cold pre-storage treatments of 1, 2, 3 and 4 weeks followed by diffuse light storage on % sprouting, number of sprouts per tuber and sprout vigor of seed potato tubers of Asante variety.

<table>
<thead>
<tr>
<th>PST (Weeks)</th>
<th>Sprouting (%)</th>
<th>Number of sprouts per tuber</th>
<th>Sprout vigor</th>
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LSD: PST: 5.417* 2.458N 0.00 5.621* 2.273* 0.00 0.4002* 0.3322* 0.3340* 0.3572* 0.3585* 0.4537* 0.2199* 0.3416* 0.3342* 0.2799* 0.2677* 0.4124* 0.6056* 2.749N 0.00 6.284* 2.542N 0.00 0.4475* 0.3714* 0.3734* 0.3993* 0.4008* 0.5073N 0.2458* 0.3819* 0.3737N 0.3130* 0.2993* 0.4610N 12.112* 5.497N 0.00 12.568* 5.083N 0.00 0.8949* 0.7429* 0.7469* 0.7987* 0.8016* 1.0145* 0.4917* 0.7639* 0.7473* 0.6259* 0.5987* 0.9221N

N, *, are Not Significant, Significant at p ≤ 0.05 respectively; DLS = Diffused Light Storage; PST = Pre-storage treatment; and PSTD = Pre-storage treatment duration. Conditions in DLS: 15.73 ± 1.37 °C and 77.35 ± 5.64 RH in season 1; 15.54 ± 1.86 °C and 80.3 ± 5.78 in season 2.