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Sweet potato can contribute to both nutritional and food security in Timor-Leste

Robert Williams[b,c], Felisberto Soares[a,b], Leandro Pereira[a,b], Bosco Belo[a,b], Abril Soares[a,b], Asep Setiawan[b], Martin Browne[b], Harry Nesbitt[b,c], William Erskine[c,d,*]

[a] Ministry of Agriculture, Forestry and Fisheries, Comoro, Dili, Timor-Leste
[b] Seeds of Life, PO Box 221, Dili, Timor-Leste
[c] Centre for Legumes in Mediterranean Agriculture (CLIMA), The University of Western Australia, 35 Stirling Highway, Crawley, WA, 6009, Australia
[d] Institute of Agriculture, The University of Western Australia, 35 Stirling Highway, Crawley, WA, 6009, Australia

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ABSTRACT

Calorie malnutrition is chronic in Timor-Leste, where vitamin A deficiency is also common. Sweet potato (*Ipomoea batatas* L. (Lam.)) is a staple in cropping in Timor-Leste, of particular importance in the diet as household cereal stocks dwindle. This study tested if promising on-station results of introduced sweet potato clones were validated on-farm under farmer management across a wide range of agro-ecologies over the 2006–2007 and 2007–2008 growing seasons using participatory varietal selection. Additionally, as the clones differed in tuberous root flesh colour we evaluated their β-carotene content and, hence, potential contribution to the alleviation of Vitamin A deficiency. In the 2006–2007 growing season three introduced clones (later released as Hohrae 1, 2 and 3) significantly out-performed the local by 29–45%, while in the next season the yields of these clones were more than double that of the local. Whereas only 29% of farmers gave positive comments about the local cultivar, 66–71% of farmers commented positively on the Hohrae clones. We assessed the β-carotene content of five introduced clones, only light orange-fleshed tuberous roots had detectable levels of β-carotene (802–1209 μg 100 g^{-1}). It was concluded that 221 g d^{-1} – slightly less than 1 cup d^{-1} – of Hohrae 3 with light orange fleshed roots will meet the requirement of an individual with Vitamin A deficiency in Timor-Leste. With an improved production potential combined with substantial β-carotene, the clone Hohrae 3 has the potential to contribute to both calorie and Vitamin A deficits in Timor-Leste.

1. Introduction

Timor-Leste is a small young tropical nation with a population of approximately 1.1 million, of whom over 80% are subsistence farmers. During 2008 more than half of the nation's rural population lived below the poverty line of US $0.88 per day (World Bank, 2008). Timor-Leste since independence has ranked third in a UN world ranking of countries with the highest percentage of chronically malnourished children (UNICEF, 2011).

A typical farm household in Timor-Leste is unable to derive a high level of personal income from 1 to 2 hectares of land. Agriculturally this mountainous country lies midway between the Javanese rice culture and the Melanesian root-based culture. With features from both directions, its staple foods are the grains maize (*Zea mays* L.) and rice (*Oryza sativa* L.) and the root crops – sweet potato (*Ipomoea batatas* L. (Lam.)) and cassava (*Manihot esculenta* Crantz). Most farm families suffer from food insecurity (WFP, 2006) producing insufficient cereal staples of maize and/or rice to last a full 12 months. Sweet potato is eaten as a supplementary food when fresh grain stocks are available. But as the maize stores decline (maize harvested mainly in March-April but also up to May) cultivated root crops assume special importance in consumption (SoL, 2009; Da Costa et al., 2013), and sweet potato is mostly consumed from August to November. Sweet potato is mainly a breakfast or snack food. The tubers are prepared in a number of ways, with the most common being boiled in water. Baked or roasted on the open fire is the second most frequent method, followed by frying in oil.

Over the period 2007–2009, national sweet potato production averaged 25,158 t from 6738 ha giving a mean yield of 3.7 t ha^{-1} (FAO, 2011). On the world stage, this level of productivity is very low being only 30% of the average global yield of 12.4 t ha^{-1}. The per capita production of sweet potato in Timor-Leste is 23 kg cap^{-1} yr^{-1}. This compares with neighbouring national per capita production of 81 kg sweet potato cap^{-1} yr^{-1} in Papua New

* Corresponding author at: Centre for Legumes in Mediterranean Agriculture (CLIMA), The University of Western Australia, 35 Stirling Highway, Crawley, WA, 6009, Australia. Tel.: +61 8 6488 1903; fax: +61 8 6488 1197.
E-mail address: william.erskine@uwa.edu.au (W. Erskine).

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Guinea and 8 kg cap^{-1} yr^{-1} in Indonesia, where the crop is a staple only in Papua and West Papua province. In Timor-Leste sweet potato is widely distributed from sea level to elevations up to *c.* 1300 m asl and is usually inter-cropped (Glazebrook et al., 2007). In addition to chronic calorie malnutrition, Vitamin A deficiency is a major nutritional problem in Timor-Leste (WHO, 2009). Ensuring that children aged 6–59 months receive enough Vitamin A may be the single most effective child survival intervention (NSD, 2010). Deficiencies in this micronutrient can cause blindness and can increase the severity of infections such as measles and diarrhoea. Bio-fortified sweet potato is an extremely rich source of provitamin A that has been shown to be effective to improve the Vitamin A status of children in Mozambique (Low et al., 2007). Burri (2011) in a recent review concluded that higher vitamin A is to be expected with orange-fleshed sweet potato and that this could prevent Vitamin A deficiency in many food-deficit countries – if orange fleshed sweet potato were substituted for white, cream, yellow or purple-fleshed sweet potatoes. This is because variety is by far the most important factor influencing the concentration of β-carotene and also because of the effectiveness of sweet potato in preventing Vitamin A deficiency.

During the Portuguese period in Timor-Leste (16th century to 1975) there was little research on sweet potato, and records of research from the subsequent Indonesian period are lost. Post-independence, the Seeds of Life (SoL) program focused on genetic improvement as it was considered that an intervention in this area was the most cost-effective route to impact given the country's post-conflict situation (Borges et al., 2009; Erskine and Nesbitt, 2009). Sweet potato germplasm was introduced to Timor-Leste in 2000 from the Regional Office for East, South East Asia and the Pacific (ESEAP) of the International Potato Centre (CIP). Clones were evaluated agronomically on station and also assessed in farmer palatability tests (Jayasinghe et al., 2003). Several locally-acceptable clones were identified as robust yielders. These initial results indicated the potential to increase sweet potato productivity in Timor-Leste through plant germplasm introduction. Furthermore, as there were orange-fleshed sweet potato accessions among the introductions with putatively high provitamin A content, the prospect arose that such clones might play an additional role to combat Vitamin A deficiency, potentially contributing to nutritional as well as food security.

This study tested if the promising results from researcher-managed cultivar comparisons made on-station were validated on-farm under farmer management across a wide range of agro-ecologies in Timor-Leste using a participatory varietal selection approach. Additionally, as the clones differed in tuberous root flesh colour we evaluated their β-carotene content and potential contribution to the alleviation of Vitamin A deficiency, as well as food security.

2. Materials and methods

2.1. Agronomic assessment – on-farm trials

Sweet potato on-farm trials were planted by farmers to compare three introduced test clones with their local check in adjacent 25 m^2 plots in the wet seasons of 2006–2007 and 2007–2008 in a similar manner to that described for maize and peanut by Williams et al. (2012a) and Williams et al. (2012b). The test clones were introduced from CIP-ESEAP Bogor as clones CIP-1 (B 0053-9), CIP-6 (AB 96001.2) and the light orange-fleshed CIP-7 (BB 97020.1) (Jayasinghe et al., 2003). B 0053-9 and BB 96001.2 were from polycross breeding at CIP-ESEAP Bogor; the female parent clone of CIP-1 was Bis-183 from Indonesia and CIP-6 derives from seed family of AB 93112 introduced from China. BB 97020.1 comes from crossing by CIP-ESEAP of B0053-9 with AB 96001.2. CIP-1, -6 and -7 have been subsequently released as cultivars Hohrae 1, 2 and 3, respectively. The test entries were selected on the basis of their performance on-station from 2001–5 (Jayasinghe et al., 2003; SoL, 2006). Sweet potato is normally planted in December/January and harvested in August. By contrast the three test clones have a shorter growth cycle from planting to harvest; with the same planting time as local varieties, they can be harvested after 4–5 months. Each farmer grew four adjacent plots allocated randomly to 3 test and 1 local and they were requested to use their traditional agronomic practices including inter-cropping with no inputs.

In the 2006–2007 season 176 trials were established in four Districts (Aileu, Baucau, Liquica and Manufahi), and in the following 2007–2008 season 147 trials were planted in six Districts with the addition of Ainaro and Bobonaro. Trials sites spanned the broad diversity of agricultural ecologies in the country from coastal lowlands up into the central mountainous ridge classified into six major agro-ecological zones (AEZ) based on rainfall and elevation (ARPAPET, 1996).

Soil pH, colour and texture were measured along with other site characteristics using the methodology described in SoL (2007). Researchers visited the trial sites approximately five times from sowing to harvest. At each visit they recorded information about the trial monitoring farmer management, household characteristics and trial progress. In-season measurements included plant condition, farmer practices, pests and diseases, wilting and other plant symptoms. On-farm trials with sweet potato were challenging because of the shorter crop generation cycle of the test clones compared to local varieties, and the tuberous nature of the crop. Compared to a grain crop, which exhibits crop maturity openly, it is problematic to monitor the stage of development in sweet potato. This makes it difficult to predict when farmers will harvest a particular trial. Additionally as sweet potatoes are harvested over an extended period, small amounts at a time, this means that at the designated harvest time, it is unlikely that the entire yield of the test crop is in the ground. Some of the roots will likely have been harvested and consumed already. Despite frequent staff visits to the sites, this was insufficient to track harvesting without researchers. As a solution to estimate plot yield in the 2006–2007 season, in the knowledge that some of the plot would be sequentially harvested prior to the agreed harvest day, staff identified with each farmer small sample areas within the 25 m^2 plot, that would remain unharvested until the farmer and researchers were together to harvest and record yield. On harvest day, therefore, a sample of the plot was harvested with the staff recording the area, and the number and weight of roots. Yield in t ha^{-1}, and the components of yield (roots m^{-2} and average root size (g)) were then calculated. In the second season, because the sample size varied over trials in 2006–2007, a standard of five random plants per plot were harvested by farmers with research staff. Yield was then estimated by multiplying the average plant production by the number of plants per 25 m^2 plot.

Data were entered into MS Excel and then we ran ANOVA (Unbalanced Model) analysis with variety and AEZ as fixed effects in the model, after the location factors of District and Sub-District had been tested for each season separately with GenStat Discovery Edition (VSN International). For the 2007–2008 season with the revised sampling procedure, we analysed by site characteristics and farmer practices with an unbalanced ANOVA design (Williams et al., 2012a,b).

After harvesting, farmers hosting trials were interviewed regarding the sweet potato clones under evaluation. They were asked about characteristics in the local and test clones that would encourage them to re-plant, and whether they would re-plant and why.