Production and utilisation of Bambaranut (*Vigna subterranea* (L.) Verdc.) in Northern and Eastern Uganda

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*Bambaranut (BN) (*Vigna subterranea* (L.) Verdc.) is a nutrient rich, drought tolerant food legume that can contribute to food security and community resilience. In Uganda however, production and utilization remain in relative obscurity. A study was conducted in Northern and Eastern Uganda to determine production and utilization practices and identify challenges and opportunities for BN improvement. Primary data on demographics, scale of production, utilization and challenges in BN production and utilization were collected from 371 farm households. Results show that more women (62%) than men (38%) are engaged in Bambaranut production for home consumption (100%), seed maintenance (50%) and sale of seeds/grains (44%). Production is low (averaging 0.2 to 0.35 acre) with few farmers involved. The crop is predominantly utilised as food (100%), consumed as a fresh boiled snack (99%) and local dishes (79%). Major challenges that confront BN farmers include scarcity of seeds (73%), limited market (65%) and difficulty in harvesting (51%). Farmers overcome these challenges by saving own seeds, obtaining seeds from neighbours and producing on a relatively small scale. Improving production practices, fostering community-research linkages to support farmers in accessing seeds and harnessing the eager participation of the youth and men will stimulate increased production and better utilisation of BN in Uganda.

**Key words:** Bambaranut, production, utilisation, practice, challenges.

INTRODUCTION

Bambaranut (*Vigna subterranea* (L.) Verdc.) is considered the third most important food legume in Africa after groundnut and cowpea (Dansi et al., 2016), with relatively high carbohydrate (63%) and protein (19%) contents and a sizeable amount of fat (6.5%) (Yao et. al., 2015). It is extremely tolerant to drought and poor soils (Mkandawire, 2007) and can replace soil nutrients through nitrogen fixation (Musa et al., 2016), making it suitable for...
the low input agricultural production systems of the dry lands of SSA (Christiansen, 2017; Hillocks et al., 2012). These attributes, alongside diversification of food sources and genetic conservation of cultivated species, make BN a strategic crop for resilience in the face of climate change (Mayes et al., 2019; NRC, 2006). It is widely acknowledged, however, that production in most regions of SSA is still on a relatively low scale with areas under BN mostly ranging from 0.2 to 3 ha (Ibrahim et al., 2018; Mubaiwa et al., 2018a; Aviara et al., 2013; Madebwe et al., 2005). This has been attributed to a number of factors including scarcity of seed and lack of knowledge or confidence among farmers (NRC, 2006). Yield is equally relatively low in SSA, averaging about 0.4 t/ha, although yields of 4 to 6 t/ha is possible under improved conditions (NRC, 2006). The relatively small quantity of BN produced is mostly consumed at household level, as fresh or dry seeds, although some portion is often sold for family income (Ibrahim et al., 2018; Mubaiwa et al., 2018a; NRC, 2006). In many parts of SSA, fresh seeds from early harvests are boiled and consumed as snacks, which constitute the predominant form in which the crop is consumed (NRC, 2006). Dry seeds on the other hand can be soaked and boiled, soaked and toasted, decorticated and mashed, or milled into flour for various preparations (Mubaiwa et al., 2018b; NRC, 2006). In addition, commercial products such as BN flour used in baked products, soup and porridge (Mubaiwa et al., 2018b), BN milk as food for under age children (NRC, 2006) or as probiotic (Murevanhema and Jideani, 2013), and canned BN seeds (NRC, 2006) have been shown to be popular, but are currently not widely produced or marketed. Given the potential for increased production and diversification of uses, BN could become a very important food security crop for resource constrained communities in the regions where it is grown (NRC, 2006; Hillocks et al., 2012). However, in the case of Uganda, there is very little documented information on BN among researchers and the farming community arguably limiting its production and utilisation. To gain an understanding of the production practices and utilisation, and hence identify challenges and opportunities for their improvement, a study was conducted in the major BN production regions of Uganda.

METHODOLOGY

The study area

A baseline survey was conducted between June and July 2019 in a total of 12 districts located in the Northern and Eastern regions of Uganda. In the Northern region, the study covered the Acholi and Lango sub regions and the Teso and Bukedi sub regions in the Eastern region. These regions are dominated by the Northern moist farmlands that transitions into the Northern farm bush and Usuk sandy farm grasslands agro ecological zones (AEZs) (Wortmann and Eledu, 1999). The soils are mostly sandy and rainfall is generally unimodal in these AEZs stretching from March/April to October (average annual temperature is >20°C and annual rainfall >1200 mm). The zones experience a long dry season from November to March (Wortmann and Eledu, 1999). Groundnuts, dry land food crops such as pigeon pea, cowpea, millet, sorghum and cash crops such as cotton, sesame and tobacco dominate these AEZs (Wortmann and Eledu, 1999).

Sampling, data collection and analysis

A multi stage sampling approach was used to select regions, districts, sub counties and households (Chauvet, 2015). At the first stage, the two regions were purposively selected, then at the second stage, a proportionate number of districts were assigned to each region on the basis of reported production levels (8 for Northern and 4 for Eastern). Individual districts and sub counties were subsequently randomly selected from each region and district, respectively at the third stage. Finally, respondents (households) were selected both purposively (previous or current BN farmer) and randomly (any BN farmer who could be located). A total of 371 respondents were selected, to whom a semi structured questionnaire was individually administered in face to face interviews (Tongco, 2007). The districts, and sub counties sampled are shown in Table 1. Information was gathered on demographics of BN farmers (age, sex, education and marital status); scale of and practices in production and utilisation of BN. Data was analysed using IBM® SPSS® Statistics Version 20 statistical software (IBM Corporation, Armonk, New York, USA). Percentages were generated by descriptive statistical analysis among the various factors investigated in the study. Chi square tests of association was used to describe the relationship between demographic characteristics and the decision to grow BN. Pearson’s correlation was used to determine the nature of the relationship between area planted with Bambaranut and quantity harvested and sold, and between quantity harvested and quantity sold.

RESULTS AND DISCUSSION

Demographics of Bambaranut farmers

Generally, more women (62%) than men (38%) engage in BN production, a trend exhibited in both regions, although the difference in proportion is slightly less in the Eastern region (65 and 35% for Northern and 56 and 44% for Eastern, respectively) (Figure 1). In these communities, the most important sources of livelihood are food crop (100%), cash crop (44%) and livestock farming (35%). This was similar for regions, gender and age, except for education level whereby those attaining tertiary education depended more on cash crop farming (60%), livestock farming (53%) and as expected, salaried employment (13%). Land for production of BN is almost entirely inherited; 95, 97 and 97% in 2016, 2017, and 2018, respectively, as opposed to bought or rented. Involvement in the production of BN was more frequent among the middle age groups and the elderly (that is, 31-60 years) in 2016 $\chi^2(10) = 24.19, p = 0.01; (\phi = 0.255, p < 0.01)$ and 2017 $\chi^2(10) = 16.06, p = 0.01; (\phi = 0.201, p < 0.01)$. The majority of the farmers in both regions had low levels of formal education, attaining/attending mostly primary
Table 1. Districts and sub-counties sampled in Northern and Eastern Uganda and corresponding number of respondents interviewed.

<table>
<thead>
<tr>
<th>District</th>
<th>Sub county</th>
<th>Northern</th>
<th>District</th>
<th>Sub county</th>
<th>Eastern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F*</td>
<td></td>
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<td>F</td>
</tr>
<tr>
<td>Agago</td>
<td>Parabongo</td>
<td>14</td>
<td>Amuria</td>
<td>Apeduru</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Wol</td>
<td>9</td>
<td></td>
<td>Willa</td>
<td>5</td>
</tr>
<tr>
<td>Gulu</td>
<td>Awach</td>
<td>12</td>
<td></td>
<td>Acowa</td>
<td>9</td>
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<tr>
<td></td>
<td>Paicho</td>
<td>13</td>
<td></td>
<td>Okungur</td>
<td>8</td>
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<tr>
<td>Kole</td>
<td>Akalo</td>
<td>12</td>
<td></td>
<td>Kapeleby ong</td>
<td>5</td>
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<tr>
<td></td>
<td>Bala TC</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lira</td>
<td>Agweng</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Aromo</td>
<td>14</td>
<td></td>
<td>Sop Sop</td>
<td>12</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Peta</td>
<td>17</td>
</tr>
<tr>
<td>Omoro</td>
<td>Bobi</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lakwana</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otuke</td>
<td>Adwari</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Okwang</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oyam</td>
<td>Aleka</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Otwal</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Pader</td>
<td>Ogom</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pader</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sub totals</strong></td>
<td>161</td>
<td>85</td>
<td></td>
<td>Sub totals</td>
<td>70</td>
</tr>
<tr>
<td><strong>Total (371)</strong></td>
<td>231</td>
<td>140</td>
<td></td>
<td>Total</td>
<td>55</td>
</tr>
</tbody>
</table>

*F = Female, M = Male.

Source: Authors

Nevertheless, majority of all the farmers were married, with a few widowed, and far less singles or separated (Figure 1D). There was however no association between sex, age (in 2018), marital status, education level and the decision to grow BN. The engagement of more women in BN production is expected because in most of these communities, women are largely responsible for the nutrition and food security of a household, besides preserving certain crops considered of great traditional value (Mpiima et al., 2019; Dansi et al., 2016; NRC, 2006). Bambaranut is considered one such crop with important nutritive and traditional value (Dansi et al., 2016; NRC, 2006). Interestingly, the younger generation (31 to 40 years) are quite involved in the production of BN, perhaps more than expected as the crop is traditionally known to be a preserve of the elderly, mostly women (NRC, 2006). The involvement of this group could in part be explained by the appreciation of the value of the crop, passed on through generations and/or myths associated with the crop, some referred to in this study. In essence, education level, age and marital status have been shown to influence adoption of agricultural technologies among farming communities (Mottaleb, 2018; Meijer et al., 2014; Kasirye, 2013). Because there are so far no ‘formal’ agricultural technologies for BN in Uganda, adoption in this context broadly refers to taking up or being involved in the production of the crop, for which there was no evidence from this study to relate it to education level, age and marital status, except age mentioned earlier. The most likely explanation for this is the fact that BN production and seed system is entirely informal (McGuire and Sperling, 2016; NRC, 2006), and in the case of Uganda, there is hardly any formal research, extension or seed supply intervention. This has been alluded to in this study by the limited training in integrated crop management undertaken by respondents. Only 48% of all respondents received any form of training in any of these practices; use of improved crop varieties, crop rotation, intercropping, use of inorganic/organic pesticides and herbicides, use of inorganic/organic fertilizer, mulching, earthing up and use of raised seed beds. Another explanation is the informal seed system (use of own seeds, acquisition from neighbor, etc.) described in
Obura et al. (2021a). Cultivation and management practices for such a crop are therefore entirely based on traditional knowledge and practices that have informally been passed on through generations (Hillocks et al., 2012; NRC, 2006). Nevertheless, the inspired involvement of the younger generation in BN production and the traditional/cultural values attached to the crop in the country point to a future for the crop and its sustenance.

**Scale and trend of Bambaranut production in Uganda**

The common perception among the respondents was that few farmers are engaged in BN production in Uganda (Figure 2). This aligns with actual figures reported by respondents whereby production is generally at a very low scale with a maximum recorded area for a single farmer being only 2 acres (Table 2). Accordingly, average
Table 2. Average area planted with and quantities of Bambaranut harvested and sold between 2016 and 2018.

| Region   | Area under Bambaranut (Acre) | Quantity of Bambaranut harvested (kg)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>0.19</td>
<td>0.19</td>
</tr>
<tr>
<td>Eastern</td>
<td>0.32</td>
<td>0.33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>Area in 2016</th>
<th>Area in 2017</th>
<th>Area in 2018</th>
<th>Quantity harvested in 2016</th>
<th>Quantity harvested in 2017</th>
<th>Quantity harvested in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>0.20</td>
<td>0.21</td>
<td>0.23</td>
<td>87</td>
<td>92</td>
<td>95</td>
</tr>
<tr>
<td>Male</td>
<td>0.27</td>
<td>0.28</td>
<td>0.28</td>
<td>118</td>
<td>106</td>
<td>128</td>
</tr>
</tbody>
</table>

Table 3. Correlations between area planted and quantities of Bambaranut harvested and sold between 2016 and 2018.

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Area in 2016</th>
<th>Area in 2017</th>
<th>Area in 2018</th>
<th>Quantity harvested in 2016</th>
<th>Quantity harvested in 2017</th>
<th>Quantity harvested in 2018</th>
<th>Quantity sold in 2016</th>
<th>Quantity sold in 2017</th>
<th>Quantity sold in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area in 2016</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Area in 2017</td>
<td>0.92</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area in 2018</td>
<td>0.87</td>
<td>0.88</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity harvested in 2016</td>
<td>0.59*</td>
<td>0.62</td>
<td>0.55</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity harvested in 2017</td>
<td>0.51</td>
<td>0.62*</td>
<td>0.55</td>
<td>0.86</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity harvested in 2018</td>
<td>0.51</td>
<td>0.44</td>
<td>0.54*</td>
<td>0.73</td>
<td>0.73</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity sold in 2016</td>
<td>0.48*</td>
<td>0.35</td>
<td>0.31</td>
<td>0.86*</td>
<td>0.56</td>
<td>0.52</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity sold in 2017</td>
<td>0.39</td>
<td>0.51*</td>
<td>0.35</td>
<td>0.56</td>
<td>0.85*</td>
<td>0.57</td>
<td>0.53</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Quantity sold in 2018</td>
<td>0.39</td>
<td>0.36</td>
<td>0.47*</td>
<td>0.48</td>
<td>0.67</td>
<td>0.86*</td>
<td>0.43</td>
<td>0.67</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Authors

acreage ranged from about 0.2 to 0.35 acre with relatively larger areas in Eastern than Northern and among men than women (Table 2). Nevertheless, production generally increased from 2016 to 2018 for Eastern region and for both women and men (Table 2). Quantity harvested and sold were equally low and followed a similar pattern to acreage (Table 2). The small areas notwithstanding, they highly corresponded to the quantity of Bambaranut harvested and sold across the years (Table 2), suggesting consistency in the decision of how much to plant and how much of the harvest to sell. The most important reasons for the low production were limited market (59%), seed scarcity (49%), limited information on production, processing and utilisation (49%), difficulty in crop management (43%) and better competing alternative legumes (39%). Interestingly however, seed scarcity (54 and 41% for Northern and Eastern, respectively) and better competing alternative legumes (46 and 26%) featured more prominently in the Northern than in the Eastern region, while limited market was eminent in the Eastern (71%) compared to Northern (52%). The seed scarcity scenario can in part be attributed to the fact that more respondents in the Northern (43%) than in the Eastern region (33%) reported seed losses due to various factors such as a failed crop and socio-political disruption to farming. This in turn is partially reflected in the relative differences in the areas planted with the crop for the two regions (Table 2). Nevertheless, for both regions, the number of farmers who did not grow the crop in the same period proportionately decreased (data not shown). Allied to this decrease is the willingness (about 97% of all respondents) to re-engage in growing the crop for food security (75%), its palatability (41%), and nutrition (29%) once seeds become available, with a similar trend for both female and male in both regions. Furthermore, the rather uncharacteristic involvement of the younger generation (31-40 years) in production could partly explain this trend. Collectively, these trends strongly suggest a scenario that offer promise for the future of the crop. Motivation for growing the crop namely; home consumption (100%), seed production/maintenance (50%) and sale of seeds/grains (44%), and acreages were quite similar for both women and men and regions, except sale of seeds/grains which was relatively higher in Eastern region (58%) than in the Northern (46%). Seed
maintenance is the practice whereby, the main reason for growing the crop is to preserve seeds and have them available for planting season to season. Evidence from most production regions of SSA supports the relatively small actual areas and low yields recorded in this study. In western Niger for example, a relatively large area of 2 ha was reported (Ibrahim et al., 2018) while much smaller areas of 1.1 and 0.8 ha in Northern Ghana (Bercie et al., 2010b) and north Eastern Nigeria (Aviara et al., 2013), respectively are said to be the most common. Yield is also reported to be relatively low in most parts of SSA, averaging 0.4 t/ha, although yields of 4 to 6 t/ha has been achieved under improved conditions (NRC, 2006). Farming in these regions is largely for subsistence and Bambaranut perfectly fits in as a typical subsistence crop, but frequently facing seed scarcity, limited demand and limited products, hence low production (NRC, 2006).

Production practices of Bambaranut in Uganda

**Planting and cropping pattern**

Planting BN, like most crops produced in the sampled regions, is synchronized with the onset of rains, being done mostly in March and April shortly after the first rains of the first season (Figure 3). A few also plant in June and July for the second season, in the Eastern region (Figure 3). In most cases, BN is planted in pure stand (79%) (Table 5), as a strip next to groundnut, and reportedly so since most practices are generally similar to that of groundnuts except that BN takes longer in the field. Where intercropping (21%) is practiced however, the most common intercrops are maize and cassava (Table 4). The reasons cited for these intercrops in Northern and Eastern regions, respectively were food security (67 and 83%), crop complementarity (architecture and non allelopathy) (16 and 39%), and higher yield (18 and 22%). Similarly for the intercrops, more women targeted food security (77%) and higher yields (24%) compared to the men (59 and 9%, respectively). Weeding BN is most often done twice, but occasionally may be less or more times depending on the weed situation in the field (Table 4). These regional trends are also exhibited for both gender and among the different age groups (data not shown), except as described for specific aspects earlier. Coinciding BN planting with the onset of rains and monocropping are practiced in nearly all BN production regions (Ibrahim et al., 2018; Bercie et al., 2013; Hillocks et al., 2012; Bercie et al., 2010b; NRC,
2006; Collinson et al., 1996). It is further reported that BN can be grown twice in a year in a region with a bimodal rainfall pattern (Bercie et al., 2013).

Although some parts of the study area tend to have a bimodal rainfall pattern, most parts have a unimodal pattern with a long rainy season stretching from March/April to November with sometimes a short dry spell in June (Wortmann and Eledu, 1999; Nsubuga et al., 2014). This allows BN to be planted twice a year in Uganda as observed for the Eastern region. There is, however, little evidence to suggest that many farmers actually plant twice, as depicted in this study where farmers tend to plant in one of either season, but not both (Figure 3), with the first season (March-June) being the main season for BN planting. Further information from Niger and Zimbabwe reveal that where BN is intercropped, the most common intercrops are cassava and maize (Mubaiwa et al., 2018; Ibrahim et al., 2018; Hillocks et al., 2012). Nevertheless, intercropping BN is generally rare in large parts of SSA where land is not a limiting factor (Hillocks et al., 2012). With respect to weeding, two times weeding normally seems to be sufficient in most parts (Ibrahim et al., 2018; Hillocks et al., 2012; Berchie et al., 2010b; NRC, 2006), although additional weeding may be required (a third or spot weeding).

### Earthing up

Another common practice done by 99.6% of all respondents is earthing up (also called mounding), during the second weeding (roughly 8 weeks after planting-WAP) (Table 4). A study in Burkina Faso revealed that the best time for earthing up is at 2 or 7 WAP, that is, before or after flowering for proper pod set and better seed yield (Ouedraogo et al., 2013). Bambaranut, unlike groundnut, has runner like stems along which flowers and subsequently pods are formed. If left uncovered, pods can be exposed to unfavorable environmental conditions resulting in poor yield (Ouedraogo et al., 2013), and arguably poor quality seeds, hence the need for earthing up. In other parts of the world, BN may alternatively be planted on ridges for the same reason as earlier stated, and for erosion control and avoidance of water logging (Hillocks et al., 2012).

### Harvesting

Harvesting is normally done in piece meal with first harvest predominantly in August and September while the last harvest is done in September and October (Figure 4). The beginning and end of the harvest period is largely determined by the time of planting and the entire harvest normally lasts about a month (Figure 4). Consequently, July is one of the last harvest months in Eastern region due to early first season (February) planting. Accordingly, the average relative maturity period by these planting and first harvest dates is 4 to 5 months for the landraces in the study sites (Figure 4). The reason for piece meal harvesting is likely due to the need to ensure a staggered supply of food and income and the need for seed preservation. Besides the timing from planting to first harvest, farmers use important changes during crop growth such as yellowing of leaves, colour and texture characteristics of a landrace, and drying of stems and leaves to determine harvest maturity and ensure good yield and high seed quality (Figure 4). However, whole plants are harvested at any one time and given the fact that BN can produce flowers for an extended period of time (up to 50 days) (Collinson et al., 1996), it is common to find pods and seeds on a plant at very different maturity stages. These and other factors such as soil and environmental conditions (Bercie et al., 2016; Berchie et al., 2012; Vurayai et al., 2011), photoperiod sensitivity (Kendabie, 2014; Berchie et al., 2013; Linnemann et al., 1995) and seed mixtures (NRC, 2006) make it difficult to determine the exact physiological maturity stage for a given landrace. Nonetheless, a report by Hillocks et al. (2012) indicated that the maturity period of most BN landraces in Zimbabwe is 5 to 6 months, while most landraces across SSA are said to mature in about 4 to 5 months (NRC, 2006).

### Other crop management practices

A routine component of the cropping system is rotation of BN with other crops, done by all respondents (100%) in

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**Table 5. Pre-cooking treatments and cooking methods for Bambaranut in Uganda.**

<table>
<thead>
<tr>
<th>Region</th>
<th>Boiling</th>
<th>Roasting</th>
<th>Local dishes</th>
<th>Pre-cooking treatment</th>
<th>Boiling</th>
<th>Roasting</th>
<th>Local dishes</th>
<th>Pre-cooking treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
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<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Northern</td>
<td>100</td>
<td>2.4</td>
<td>80.5</td>
<td>40.8</td>
<td>20.4</td>
<td>80</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Eastern</td>
<td>96</td>
<td>24</td>
<td>81.6</td>
<td>16</td>
<td>49.6</td>
<td>80</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98.7</td>
<td>9.7</td>
<td>80.9</td>
<td>32.4</td>
<td>30.3</td>
<td>80</td>
<td>1.4</td>
<td></td>
</tr>
</tbody>
</table>

*Boiling of fresh pods only. Local dishes include 'dek ngor’/agira’ or ‘emagire’ (most common), dry cooked and pasted/fried, dry cooked and mashed with sweet potato. Dry seeds only.

Source: Authors
both regions. The crops in rotation were not specified, but are most likely the other commonly cultivated crops by the respondents which are the cereals, maize (77%), sorghum (45%) and finger millet (41%), or the root crops, cassava (81%) and sweet potatoes (46%). Field pests and diseases are reportedly not very serious problems to warrant any action or even when they become serious, 97% of farmers do nothing about them. On the other hand, storage pests and diseases may occasionally prove problematic, but farmers use various methods to manage the situation (Table 6). Post-harvest handling and seed management practices of BN in Uganda have been described in detail in Obura et al. (2021a).

Utilisation of Bambaranut

Bambaranut is largely produced for food, but occasionally used as medicine and for cultural purposes (Figure 5). As food, the nut is generally consumed in fresh and dry forms. In fresh form, the pods are boiled and seeds eaten as a snack mainly at the beginning of the harvest period (Table 5). In the dry form, the seed is either boiled as a whole grain or after being crushed. Choice of whole or crushed grains depends on the dish to be prepared. Boiled grains are either pasted with groundnuts/sesame paste or mashed with sweet potatoes. Crushed and dehulled dry grains make a special delicacy called ‘dek ngor’/’lagira’ (in Luo, Northern region) or ‘emagire’ (in Ateso, Eastern region) (Table 5). In some cases, the dry grain is soaked and toasted for a snack. Prior to cooking however, a number of procedures are applied to the dry grains to ease cooking and prepare the particular type of local dish (Table 5). These procedures are similar for both men and women in both regions (Table 5). Medicinal use, which featured more prominently among the older groups of ‘51-60’s (22.4%) and ‘over 60’ (22%) age groups, is reportedly for treatment of diarrhea and cough (chewed as raw or boiled fresh young/mature seeds). Additionally, the fully mature fresh or dry boiled seeds are used for treatment of aches (body and stomach), kidney problems, measles and relieving the pain associated with afterbirth in mothers of new born. They are also suggested by some, especially men, to act as an aphrodisiac. Culturally, there are several myths associated with Bambaranut, many of which seem to relate to conservation of the crop. Reports from this study suggest that BN is used to prevent crop damage from a ‘witch’ when planted along the boundary of groundnuts (both regions), prevent crop damage from hailstorms and lightening (Eastern-Teso), and can result in massive crop failure and death if one stops cultivating it (Northern-Acholi).

Similar to most traditional food crops in the country, BN is primarily produced for subsistence, whereby domestic food supply and seed maintenance are the major motivating factors for most communities. Consequently, the range of products from such a crop as BN is very...
Table 6. Mitigation of the most important challenges to Bambaranut production and utilisation in Uganda.

<table>
<thead>
<tr>
<th>Region</th>
<th>Seed scarcity</th>
<th>Limited market</th>
<th>Difficulty in harvesting</th>
<th>Difficulty in drying</th>
<th>Storage pests and diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant own saved seeds</td>
<td>Obtain from neighbour</td>
<td>Consume fresh boiled</td>
<td>Sell in local market</td>
<td>Plant small area</td>
</tr>
<tr>
<td>Northern</td>
<td>44.3</td>
<td>16.4</td>
<td>20.7</td>
<td>13.2</td>
<td>25.2</td>
</tr>
<tr>
<td>Eastern</td>
<td>56.8</td>
<td>10.4</td>
<td>9.6</td>
<td>40.0</td>
<td>28.0</td>
</tr>
</tbody>
</table>

Source: Authors

limited, having only a few local products for domestic use and limited sale within the communities (Hillocks et al., the younger generation (21-40 years) the encouraging involvement of men (38% of all BN farmers in the two regions) in BN production and utilisation. While this may be considered a relatively low percentage for men’s 2012; Namazi, 2009). Yet several products can be derived from BN due to its relatively high starch and protein contents (NRC, 2006). In southern Africa for example, BN flour is widely used in making baked products, soups and porridge (Mubaiwa et al., 2018b). Similarly, milk from BN, demonstrated to be of comparable quality to that of soybean and shown to be acceptable to both mothers and their babies, is suggested to have great potential in the nutrition of under age children (NRC, 2006). In Zimbabwe, canned BN beans are an important commercial product widely marketed in the urban areas of the country (NRC, 2006). Bambaranut can therefore be not only a major source of energy and proteins in the diets of communities, but a good source of income if production and utilisation can be improved. Additionally, consolidation of information on the reported medicinal uses and the basis for such medicinal properties would further broaden
Challenges of Bambaranut production and utilisation in Uganda

Bambaranut farmers in the study area face several challenges, the most important ones being scarcity of seed, limited market and difficulty in harvesting (Figure 6). Other relatively important challenges are post-harvest related and include poor storage facilities, damage by storage pests and diseases and difficulty in drying (prolonged drying time). These are cross-cutting challenges in both regions, albeit with slight variations in importance (Figure 6). The underlying cause of seed scarcity is realistically linked to few farmers producing on relatively very small, while limited market is linked to low demand incited by relatively limited uses and lack of information discussed earlier. According to Obura et al. (2021a), the labour related challenge of ‘difficulty in harvesting’ is due to the fact that most farmers in Uganda use the hand hoe to dig up the pods regardless of the time of harvest or the soil conditions. In many parts of SSA however, difficulty in harvesting is suggested to arise mostly from the timing of harvest with respect to soil moisture conditions and maturity stage (NRC, 2006). When the soil is moist and soft enough and the crop is at an early maturity stage (yellowing of leaves), the plants can easily be pulled out (NRC, 2006). However, when the soil is dry and the crop is at a late maturity stage (with dry stems and senesced leaves), the plants has to be dug out and pods collected individually, hence making it more labour intensive (Obura et al., 2021a; NRC, 2006).

Despite all these challenges, persistent farmers often devise means to address most of them, hence, continue to grow BN for reasons such as food security and seed maintenance discussed under ‘scale and trend of Bambaranut production’. The mitigation measures for difficulty in seed access for example include saving own seeds, buying in the local market and obtaining from the neighbor (Table 6). On the other hand, the involvement of most or all family members in harvesting reduces the tediousness of harvesting. Although limited market features prominently among the challenges, the issue perhaps relates more to market for bulk sale of dry grains or seeds rather than no market at all, because the majority of respondents who grow the crop admit that there is always market for the fresh boiled snack within the village. They therefore plant small acreages mainly for home consumption and sell in the local market to ensure they meet the relatively low demand (Table 6).

Interestingly, the problem of ‘hard to cook’ (HTC) that ranks highly among challenges in other parts of SSA for example in Zimbabwe (Mubaiwa et al., 2017), Nigeria (Aviara et al., 2013) and Ghana (Berchie et al., 2010b) apparently was not as serious in Uganda (Figure 6). The explanation for this can be found in the ways the crop is mostly consumed, that is, fresh boiled snack and a local dish known as ‘dek ngor’emagire’, and the preparation methods prior to cooking namely decortication and soaking (in ‘utilisation of Bambaranut’). Decortication removes the hard seed coat implicated in HTC, while soaking softens it and allows prior permeation of water into the seeds, thereby easing the cooking (Mubaiwa et al., 2017). The root cause of all these challenges is the fact that BN has for long remained an ‘orphan’ crop in the...
Promising trends in production and seed utilisation of Bambaranut in Uganda

Opportunities for improving production and resilience and hope for agricultural sustainability.

Thus, there has hardly been any crop improvement or production of BN with minimal resources point towards farmers to overcome numerous obstacles and continue production. Production figures in Uganda revealed that quantities management (al., 2010b). Taken together, the self-driven efforts by BN farmers to overcome numerous obstacles and continue production of BN with minimal resources point towards resilience and hope for agricultural sustainability.

Beyond the farming communities

Research to build and consolidate basic information on Bambaranut: Quite encouraging research has been conducted on BN in such areas of agronomy (Chai et al., 2016; Mabhaudhi, 2013; Collinson et al., 1996); seed quality (Mandizvo and Odindo, 2019; Chibarabada et al., 2015; Chibarabada et al., 2014); nutritional characteristics (Mubaiwa et al., 2018b; Yao et al., 2015; Okpuzor et. al., 2010); and socio-economic aspects (Ibrahim et al., 2018; Mubaiwa et al., 2018a; Hillocks et al., 2012; Berchie et al., 2010b) among others. While these are still not considered to be comprehensive work on the crop in comparison to research on other grain legumes in SSA, they are in stark contrast to the efforts in Uganda where there has been extremely limited documented formal research on BN (Obura et al., 2021a). There is thus a huge opportunity for researchers in Uganda to generate extensive information on BN that will lead to better understanding and appreciation of the crop among farmers, research institutions, development partners and government agencies. This will in turn improve the crop’s relatively unknown reputation as one with vast potential for food security and community resilience. Priority areas of research will include collection and documentation of all available landraces in the country, more detailed and specific surveys e.g. targeting farmers preferences for landraces; agronomic performance of landraces of Uganda; survey to identify and characterise Bambaranut pests and diseases in Uganda; developing pests and diseases management strategies; variety development and crop improvement, developing value chains for different Bambaranut products in the country.

Germplasm management: Several landraces exist in the country (at least 14 were encountered during this survey). However, only three are under maintenance at the National Gene Bank of Uganda (NGBU) (NARO, 2022) while a few more are perhaps being maintained at the National Semi Arid Resources Research Institute (NaSARRI). It is clear, therefore, that there is need for a rigorous collection targeting the entire country, of all the available landraces. These and the already identified types should undergo proper documentation and management to ensure their availability if and when needed by breeders for varietal development or breeding research, community seed producers for seed production and maintenance, and institutions of learning for learning.
purposes. For good purpose however, the International Institute of Tropical Agriculture (IITA), Nigeria (1815), the Institute of Research for Development (IRD), France (1000), and The Southern African Development Community (SADC) (unspecified) have huge collections of BN germplasm that are being maintained in their gene banks (Aliyu et al., 2016). Most, if not all the materials encountered in this baseline survey or maintained at NaSARRI and the NGBU are likely part of the collections mentioned above. The relevance of such huge collections become clear when BN improvement programs are initiated in the country that require a pool of diverse germplasm, when there is need for introductions of new types to the country’s current pool of germplasm and once various research activities are to be undertaken to consolidate information on the crop.

Seed production and maintenance: As research goes on in the various aspects of the crop, a seed production scheme can in the meantime be initiated to address the current seed gap. Seeds of preferred/commonly cultivated types in each region should be maintained and limited quantities produced on demand to serve the interest of groups and/or individuals in need of seeds that may not be readily available in their areas. Research institutes in the predominant production areas could take the lead and engage local seed business groups (LSBs) to provide arguably the most suitable pathway through which a functional seed system can be achieved (Mastenbroek, 2015). Already this model has shown great promise for both commercial varieties of ‘priority’ crops and traditional food crops in those regions (Mastenbroek et al., 2021; Mastenbroek, 2015). This will ensure consistent availability of seeds for planting, hence, sustained production and consumption. The obvious challenge with this model is the resources needed for maintenance and production of the seeds at the research stations or by the community and/or LSBs. In the very beginning, it will take the dedication and sacrifice of legumes research scientists in those institutes to allocate some minimal resources to BN and carry it along their core legumes research activities.

Community sensitization: Climate change and climate variability and their impacts, adaptation and mitigation and community involvement should be emphasized. This can be through public and on farm programs led by relevant government institutions, development organizations with food security programs and other organizations that are within or work closely with communities.

CONCLUSIONS

Bambaranut production in Uganda is at a relatively low scale and the crop is utilised in just a handful of ways for a number of reasons. Production practices and utilisation are very similar to what exist in other regions where the crop is cultivated. There are however, promising trends of increase in production of BN in Uganda in terms of quantity and quality that can be produced and sold. This can be supported by similar interest and engagement of the youth, women and men in the production and utilisation of the crop, willingness by former farmers to re-engage in production, and appreciation among farmers of the climate resilient attributes of BN. While many challenges still exist, numerous opportunities equally exist for research, seed production and diversification of uses, within and beyond the communities. Subsequently, improving production practices, supporting farmers to easily access seeds and other services through community-research linkages and harnessing the eager participation of the youth and men will stimulate increased production and better utilisation of BN in Uganda.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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