Performance of Potatoes under Irrigation in the Dry Parts of Kenya

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Abstract  Potato is a cool season crop and in Kenya, it is generally grown in the cool highlands between 1500 and 3500 meters above sea level. It can also be grown in warmer areas as long as water is available and temperatures are not very high. In the irrigation schemes in Kenya, paddy rice is the main food crop; this is rotated with maize. There is need to increase productivity of these irrigation schemes through crop diversification. Potatoes can be a good alternative crop because it is fast maturing. Work was done to evaluate performance of potatoes at Mwea Irrigation Agricultural Development (MIAD) Centre in Kirinyaga County and at National Irrigation Board (NIB) irrigation schemes at Bura and Perkerra between 2013 and 2015. Generally, potato varieties took a shorter time to mature and had lower yields in the irrigation schemes than they normally do in the cool highlands. At Mwea, ware-sized tubers averaged 80% of the total yields. Average yields at Mwea and Perkerra were much higher than at the hotter Bura site; there were no ware-sized tubers at Bura. Potato varieties that were released into Kenya a long time ago such as Desiree, Romano, Pimpernel, Roslin Eburu and Roslin Bvumbwe performed well at Mwea and Perkerra. These varieties should be promoted in the respective areas where they performed well.

Keywords Irrigated potatoes; Performance; Yields

Introduction
Kenya’s economy is mainly agriculture-based. Consequently low food crop production leads to food insecurity. Over eighty percent of Kenya’s landmass is hot and dry and therefore unsuitable for arable farming. Crop failures due to low and erratic rainfall are rampant in most parts of the country leading to perennial food shortage. Luckily, the country is endowed with fresh-water rivers which have traditionally been used mainly for production of paddy rice under irrigation. The Kenyan government having realized the huge potential the country has in improving food sufficiency through prudent use of irrigation water is putting a lot of emphasis into expanding the irrigation schemes in the country. In addition, there is need to increase productivity of these irrigation schemes through crop diversification. In most of these irrigation schemes, paddy rice is the main food crop; it is rotated with maize. The irrigation board has been seeking alternative crop with which to rotate with rice because maize takes a long time to mature; a short-duration crop such as potatoes could fill in the gap. Introduction of potatoes as one of the rotational crops to replace maize may play an important role in increasing productivity of the irrigation schemes since potato matures early and has many uses. Work to evaluate performance of potatoes at Perkerra irrigation scheme was initiated in October 2013-February 2014 season. Later, it was expanded to Bura irrigation scheme and Mwea Irrigation Agricultural Development (MIAD) Centre.

Materials and Methods
Site characterization
The study was carried out at Mwea Irrigation Agricultural Development (MIAD) Centre in Mwea, Kirinyaga County in the former Central Province and at National Irrigation Board (NIB) irrigation scheme at Bura. The Mwea
site lies at an altitude of 1067 meters above sea level, latitude 0° 28' 30" N and longitude 35° 56' 20" E. The average annual rainfall is 654 mm with a bimodal distribution and potential evapotranspiration is 1360 mm. A long rainy season occurs between March and May while a short rain season is between October and December (Jaetzold et al., 2006). The mean air temperature ranges from 16.8 to 32.4 °C with an average of 24.6 °C. The station is situated in agro ecological zone 5 (LM5) and the major land uses are irrigated and dryland farming, pastoralism involving rearing of cattle, goats, sheep, and camels and beekeeping. The soils are volcanic fluvisols of sandy/silty clay loam texture; they are slightly acid to slightly alkaline, fertile with adequate P, K, Ca and Mg but low in N and C (UNESCO, 1977).

Bura irrigation scheme is located about 150 km South East of Garissa Town in Tana River County in the former Coast province.

Perkerra irrigation scheme is situated about 100 km north of Nakuru in Marigat township, Baringo County, in the former Rift Valley Province. It lies at an altitude of 1067 meters above sea level, latitude 0° 28' 30" N and longitude 35° 56' 20" E. The average annual rainfall is 654 mm with a bimodal distribution and potential evapotranspiration is 1360 mm. A long rainy season occurs between March and May while a short rain season is between October and December (Jaetzold et al., 2006a). The mean air temperature ranges from 16.8 to 32.4 °C with an average of 24.6 °C. The station is situated in agro ecological zone 5 (LM5) and the major land uses are irrigated and dryland farming, pastoralism involving rearing of cattle, goats, sheep, and camels and beekeeping. The soils are volcanic fluvisols of sandy/silty clay loam texture; they are slightly acid to slightly alkaline, fertile with adequate phosphorus, potassium, calcium and magnesium but low in nitrogen and carbon (UNESCO, 1977).

**Experimental materials and procedure**

At Mwea, the experiment was planted out on 1st October 2014 while at Bura, it was planted on 27th August 2014. At Perkerra, it was carried out for two seasons; first season was planted on 6th November 2013 while the second season was planted on 21st August 2014. At all the three sites, the crop was harvested sequentially as the varieties matured at different times. The experimental materials planted at the three sites are given below (Table 1).

| Table 1 Potato genotypes used in the study |
|-----------------|----------------|-----------------|-----------------|
| **Bura** | **Mwea** | **Perkerra (S1)** | **Perkerra (S2)** |
| 1 | Kenya Furaha | Kenya Furaha | Arka | Romano |
| 2 | Romano | Desiree | Asante | Ngure |
| 3 | Tigoni | Kenya Sifa | Bishop Gitonga | Kenya Furaha |
| 4 | Shangi | Sterling | RoslinEburu (B53) | Kenya Baraka |
| 5 | DuthRobyjn | Romano | RoslinBvumbwe | Sherekea |
| 6 | Sterling | Kenya Karibu | Desiree | Pimpernel |
| 7 | Sherekea | Ngure | Dutch Robyjn | RoslinEburu (B53) |
| 8 | Kenya Karibu | Kenya Mavuno | Kenya Baraka | Kenya Mavuno |
| 9 | Kenya Baraka | Pimpernel | Kenya Furaha | Shangi |
| 10 | Kenya Mavuno | Sherekea | Kenya Karibu | Kenya Karibu |
| 11 | Ngure | Shangi | Kenya Mavuno | Asante |
| 12 | Meru Mugaruro | Meru Mugaruro | Kenya Mpya | Tigon |
| 13 | Asante | Tigoni Long | Kenya Sifa | Roslin Bvumbwe |
| 14 | RoslinTana | Roslin Eburu (B53) | Meru Mugaruro | RoslinTana |
| 15 | Pimpernel | Pimpernel | Dutch Robyjn |
| 16 | Roslin Bvumbwe | RoslinTana | Meru Mugaruro |
| 17 | Roslin Eburu (B53) | Romano | Sterling |
| 18 | Shangi |
| 19 | Sherekea |
| 20 | Sterling |
| 21 | Tigoni |
In each site, the experiment was laid out as a randomized complete block design replicated three times. Furrows, 75 cm apart were dug and potatoes were planted 30 cm apart on the shoulder of the furrows. Each plot consisted of 5 rows each row having 12 plants totalling to 60 plants per plot. During planting, Diammonium phosphate (18% N: 46% P$_2$O$_5$) was applied at the recommended rates of 500 kg ha$^{-1}$ in furrows before planting. Watering was done through furrow irrigation by gravity when need arose. Weeding, earthing-up and spraying against pests and late blight were carried out as per recommendations for potato production in Kenya (KARI, 2008).

**Data collection**

During plant growth, data collected included number of emerged plants per plot (taken 45 days after planting) and number of plants that survived until harvest. This data was used to calculate % stand establishment and % plant survival, respectively. When the plants were mature (varieties matured at different times) all the plants that survived in a plot were harvested. Data collected on plot basis included number and weights of tubers of different sizes i.e., <30, 30-60 and 60< mm in diameter. This data was used to calculate total yields (ton/ha) and % ware potato yields.

**Data analysis**

Data was analysed using Genstat statistical package, 14$^{th}$ edition (Payne et al., 2011) and means separated using Fisher’s Protected LSD Test at 5% (Steel and Torrie, 1980).

**Results and Discussion**

Soils in the three sites were slightly basic (Table 2). The pH is a little bit on the higher side because potatoes do best at pH 5.5 to 6.5 (KARI, 2008).

<table>
<thead>
<tr>
<th>Variety</th>
<th>pH</th>
<th>N %</th>
<th>P (ppm)</th>
<th>K (Me%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perkerra</td>
<td>7.80</td>
<td>0.038</td>
<td>39</td>
<td>0.549</td>
</tr>
<tr>
<td>Bura</td>
<td>7.70</td>
<td>0.059</td>
<td>19</td>
<td>1.00</td>
</tr>
<tr>
<td>Mwea</td>
<td>7.3</td>
<td>0.061</td>
<td>11</td>
<td>0.601</td>
</tr>
</tbody>
</table>

(a) Mwea

Shangi reigned high in terms of emergence; survival rate was also high at Mwea (Table 3). Generally, survival rate
of all potato varieties was more than 60% while emergence ranged from 20 to 91% (Table 3). All the varieties took less than 100 days to mature.

Based on the number of plants that survived, Pimpernel gave the highest yield of 21.14 ton/ha followed by Shangi (Table 4). The six highest yielding varieties were Pimpernel (21.14), Shangi (19.71), Romano (19.6), Desiree (18.74), Kenya Mavuno (17.54) and Ngure (17.4 ton/ha). Most varieties gave a high percentage (over 70%) ware sized tubers (Table 4). These are the table tubers used for processing and domestic consumption.

Table 4 Total yields (ton/ha) and the % ware sized tubers harvested at Mwea

<table>
<thead>
<tr>
<th>Variety</th>
<th>Total yields (ton/ha)</th>
<th>SE</th>
<th>% ware (60 mm ≤)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pimpernel</td>
<td>21.14</td>
<td>2.238</td>
<td>71.14</td>
</tr>
<tr>
<td>Shangi</td>
<td>19.71</td>
<td>3.165</td>
<td>75.8</td>
</tr>
<tr>
<td>Romano</td>
<td>19.6</td>
<td>2.46</td>
<td>82.55</td>
</tr>
<tr>
<td>Desiree</td>
<td>18.74</td>
<td>3.165</td>
<td>84.85</td>
</tr>
<tr>
<td>Kenya Mavuno</td>
<td>17.54</td>
<td>2.754</td>
<td>76.23</td>
</tr>
<tr>
<td>Ngure</td>
<td>17.4</td>
<td>2.754</td>
<td>78.28</td>
</tr>
<tr>
<td>Kenya Furaha</td>
<td>15.11</td>
<td>2.238</td>
<td>81.2</td>
</tr>
<tr>
<td>Sterling</td>
<td>13.58</td>
<td>2.789</td>
<td>92.56</td>
</tr>
<tr>
<td>Sherekea</td>
<td>13.55</td>
<td>2.754</td>
<td>76.75</td>
</tr>
<tr>
<td>Kenya Sifa</td>
<td>8.79</td>
<td>3.165</td>
<td>87.6</td>
</tr>
<tr>
<td>Kenya Karibu</td>
<td>8.56</td>
<td>2.238</td>
<td>75.23</td>
</tr>
<tr>
<td>Meru Mugaruro</td>
<td>6.44</td>
<td>2.258</td>
<td>78.42</td>
</tr>
<tr>
<td>Tigoni Long</td>
<td>4.42</td>
<td>3.911</td>
<td>77.83</td>
</tr>
<tr>
<td>Roslin Eburu (B53)</td>
<td>3.6</td>
<td>2.46</td>
<td>88.33</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>13.44</strong></td>
<td><strong>80.48</strong></td>
<td></td>
</tr>
</tbody>
</table>

For Pimpernel, Shangi and Ngure, over 60% of potential yields were realised (Table 5). There was a significant

Table 5 Potential and realised yields at Mwea

<table>
<thead>
<tr>
<th>Variety</th>
<th>*Potential yield (ton/ha)</th>
<th>Realised yields (ton/ha)</th>
<th>% potential yield realised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pimpernel</td>
<td>34.67</td>
<td>21.14</td>
<td>60.97</td>
</tr>
<tr>
<td>Shangi</td>
<td>30.38</td>
<td>19.71</td>
<td>64.88</td>
</tr>
<tr>
<td>Romano</td>
<td>40.4</td>
<td>19.6</td>
<td>48.51</td>
</tr>
<tr>
<td>Desiree</td>
<td>45.14</td>
<td>18.74</td>
<td>41.52</td>
</tr>
<tr>
<td>Kenya Mavuno</td>
<td>46.83</td>
<td>17.54</td>
<td>37.45</td>
</tr>
<tr>
<td>Ngure</td>
<td>28.09</td>
<td>17.4</td>
<td>61.94</td>
</tr>
<tr>
<td>Kenya Furaha</td>
<td>43.08</td>
<td>15.11</td>
<td>35.07</td>
</tr>
<tr>
<td>Sterling</td>
<td>42.86</td>
<td>13.58</td>
<td>31.68</td>
</tr>
<tr>
<td>Sherekea</td>
<td>33.32</td>
<td>13.55</td>
<td>40.67</td>
</tr>
<tr>
<td>Kenya Sifa</td>
<td>29.53</td>
<td>8.79</td>
<td>29.77</td>
</tr>
<tr>
<td>Kenya Karibu</td>
<td>30.62</td>
<td>8.56</td>
<td>27.96</td>
</tr>
<tr>
<td>Meru Mugaruro</td>
<td>15.5</td>
<td>6.44</td>
<td>41.55</td>
</tr>
<tr>
<td>Tigoni Long</td>
<td>30.98</td>
<td>4.42</td>
<td>14.27</td>
</tr>
<tr>
<td>Roslin Eburu (B53)</td>
<td>19.17</td>
<td>3.6</td>
<td>18.78</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>33.61</strong></td>
<td><strong>13.44</strong></td>
<td><strong>39.64</strong></td>
</tr>
</tbody>
</table>

Note: *= Assuming 100% plant emergence and 100% survival
(P≤0.05) and positive correlation between potential yields and realised yield (r=0.64). This implies that most varieties that are potentially high yielding had most of it realised.

(a) Bura

Percent plant emergence was generally high at Bura; Ngure had the highest emergence (93.89%) followed by Kenya Karibu (Table 6). Shangi fared badly with 47% emergence and 47% plant survival. Although the average percent plant emergence was higher in Bura than in Mwea, the opposite was true for plant survival and total yields (Tables 3, 4 and 6). In Bura there were no ware-sized tubers. The lower average tuber yields realised at Bura (8.68 ton/ha) than at Mwea (13.44 ton/ha) could be due to high temperatures in Bura than at Mwea. The high temperatures could also be responsible for lack of ware-sized tubers at Bura. However, in both sites, potential yields realised were less than 50% (Tables 5 and 7).

Table 6 Potato field establishment, plant survival, days to maturity and yields at Bura

<table>
<thead>
<tr>
<th>Variety</th>
<th>Mean % plant emergence SE</th>
<th>Mean % plant survival SE</th>
<th>Days to Maturity SE</th>
<th>Total yields (ton/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asante</td>
<td>42.22 8.49</td>
<td>56.06 14.40</td>
<td>62 0.82</td>
<td>2.87</td>
</tr>
<tr>
<td>Dutch Robyjn</td>
<td>86.11 8.49</td>
<td>56.88 14.40</td>
<td>68 0.82</td>
<td>12.04</td>
</tr>
<tr>
<td>Kenya Baraka</td>
<td>69.45 8.49</td>
<td>54.57 14.40</td>
<td>61 0.82</td>
<td>8.4</td>
</tr>
<tr>
<td>Kenya Furaha</td>
<td>88.41 10.51</td>
<td>58.03 17.81</td>
<td>70 1.02</td>
<td>9.67</td>
</tr>
<tr>
<td>Kenya Karibu</td>
<td>89.54 7.39</td>
<td>68.7 12.53</td>
<td>64 0.71</td>
<td><strong>14.03</strong></td>
</tr>
<tr>
<td>Kenya Mavuno</td>
<td>69.45 8.49</td>
<td>61.22 14.40</td>
<td>64 0.82</td>
<td>7.86</td>
</tr>
<tr>
<td>Meru Mugaruro</td>
<td>87.78 8.49</td>
<td>46.44 14.40</td>
<td>64 0.82</td>
<td>4.03</td>
</tr>
<tr>
<td>Ngure</td>
<td>93.89 8.49</td>
<td>68.89 14.40</td>
<td>60 0.82</td>
<td>10.67</td>
</tr>
<tr>
<td>Pimpernel</td>
<td>75.00 8.49</td>
<td>82.9 14.40</td>
<td>68 0.82</td>
<td><strong>14.35</strong></td>
</tr>
<tr>
<td>Romano</td>
<td>79.44 8.49</td>
<td>70.99 14.40</td>
<td>65 0.82</td>
<td>8.5</td>
</tr>
<tr>
<td>Roslin Bvumbwe</td>
<td>81.67 8.49</td>
<td>52.23 14.40</td>
<td>70 0.82</td>
<td>4.86</td>
</tr>
<tr>
<td>Roslin Eburu (B53)</td>
<td>74.44 8.49</td>
<td>54.14 14.40</td>
<td>61 0.82</td>
<td>14.25</td>
</tr>
<tr>
<td>Roslin Tana</td>
<td>46.11 8.49</td>
<td>57.67 14.40</td>
<td>60 0.82</td>
<td>2.42</td>
</tr>
<tr>
<td>Shangi</td>
<td>47.22 8.49</td>
<td>47.17 14.40</td>
<td>70 0.82</td>
<td>12.44</td>
</tr>
<tr>
<td>Sherkeea</td>
<td>85.55 8.49</td>
<td>54.91 14.40</td>
<td>65 0.82</td>
<td>5.3</td>
</tr>
<tr>
<td>Sterling</td>
<td>75.56 8.49</td>
<td>73.17 14.40</td>
<td>68 0.82</td>
<td>12.44</td>
</tr>
<tr>
<td>Tigoni</td>
<td>44.44 8.49</td>
<td>53.68 14.40</td>
<td>65 0.82</td>
<td>7.25</td>
</tr>
<tr>
<td>Mean</td>
<td><strong>72.72 8.55</strong></td>
<td><strong>59.86 14.49</strong></td>
<td>65.03 0.83</td>
<td><strong>8.68</strong></td>
</tr>
</tbody>
</table>

On average, only 45 % of potential yields was realised at Bura (Table 7). There was a significant (P≤0.05) and positive correlation between potential yields and realised yield (r=0.75). This implies that most varieties that have potentially high yields had most of it realised.

(c) Perkerra

During the first season at Perkerra, mean % plant emergence was 59.4 with 8 varieties showing over 70 % mean plant emergence (Table 8). Yields were much higher (15.92) than at Mwea and Bura. The six most productive varieties were Asante (28.64), Dutch Robyjn (27.46), Roslin Eburu (23.21), Kenya Mavuno (22.42), Pimpernel (22.92) and Roslin Bvumbwe (22.47 ton/ha).

Thirteen varieties had over 50% of their potential yields realised (Table 9).

During the second season at Perkerra, mean % plant emergence was 52.07 with Sterling and Ngure leading the pack (Table 10). The plants took the longest time to mature (100.24) compared to Mwea and Bura (Table 3, 6, 8, 10). Total yields realised at Perkerra during the second season ranged from 14.796 ton/ha (Dutch Robyjn) to 2.106 ton/ha for
Table 7 Potential and realised yields at Bura

<table>
<thead>
<tr>
<th>Variety</th>
<th>Realised yields (ton/ha)</th>
<th>* Potential yields (ton/ha)</th>
<th>% potential yield realised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asante</td>
<td>2.87</td>
<td>12.09</td>
<td>23.74</td>
</tr>
<tr>
<td>Dutch Robyn</td>
<td>12.04</td>
<td>24.56</td>
<td>49.02</td>
</tr>
<tr>
<td>Kenya Baraka</td>
<td>8.4</td>
<td>22.16</td>
<td>37.91</td>
</tr>
<tr>
<td>Kenya Furaha</td>
<td>9.67</td>
<td>18.84</td>
<td>51.33</td>
</tr>
<tr>
<td>Kenya Karibu</td>
<td>14.03</td>
<td>22.81</td>
<td>61.51</td>
</tr>
<tr>
<td>Kenya Mavuno</td>
<td>7.86</td>
<td>18.49</td>
<td>42.51</td>
</tr>
<tr>
<td>Meru Mugaruro</td>
<td>4.03</td>
<td>9.88</td>
<td>40.79</td>
</tr>
<tr>
<td>Ngure</td>
<td>10.67</td>
<td>16.49</td>
<td>64.71</td>
</tr>
<tr>
<td>Pimpernel</td>
<td>14.35</td>
<td>23.07</td>
<td>62.2</td>
</tr>
<tr>
<td>Romano</td>
<td>8.5</td>
<td>15.07</td>
<td>56.4</td>
</tr>
<tr>
<td>Roslin Bvumbwe</td>
<td>4.86</td>
<td>11.38</td>
<td>42.71</td>
</tr>
<tr>
<td>Roslin Eburu (B53)</td>
<td>14.25</td>
<td>35.36</td>
<td>40.3</td>
</tr>
<tr>
<td>Roslin Tana</td>
<td>2.42</td>
<td>9.08</td>
<td>26.65</td>
</tr>
<tr>
<td>Sherekea</td>
<td>5.3</td>
<td>11.27</td>
<td>47.03</td>
</tr>
<tr>
<td>Sterling</td>
<td>12.44</td>
<td>22.1</td>
<td>56.29</td>
</tr>
<tr>
<td>Tigoni</td>
<td>7.25</td>
<td>30.34</td>
<td>23.9</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>8.68</strong></td>
<td><strong>18.94</strong></td>
<td><strong>45.44</strong></td>
</tr>
</tbody>
</table>

Note: *= Assuming 100% plant emergence and survival

Table 8 Field establishment, plant survival, days to maturity and yields of potato varieties during the first season at Perkerra

<table>
<thead>
<tr>
<th>Variety</th>
<th>Mean % plant emergence</th>
<th>Mean % plant survival</th>
<th>Days to maturity</th>
<th>Total yields (ton/ha)</th>
<th>% ware (60 mm ≤)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dutch Robyn</td>
<td>90</td>
<td>86.4</td>
<td>74</td>
<td>27.46</td>
<td>9.94</td>
</tr>
<tr>
<td>Kenya Mavuno</td>
<td>84.4</td>
<td>93.2</td>
<td>66</td>
<td>22.42</td>
<td>21.82</td>
</tr>
<tr>
<td>Asante</td>
<td>78.9</td>
<td>91.8</td>
<td>66</td>
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Table 9 Potential and realised yields during the first season at Perkerra

<table>
<thead>
<tr>
<th>Variety</th>
<th>Realised yields (ton/ha)</th>
<th>* Potential yields (ton/ha)</th>
<th>% potential yield realised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dutch Robyjn</td>
<td>27.46</td>
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<td>79.5</td>
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<td>39.8</td>
<td>71.96</td>
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<td>71.23</td>
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<td>70.11</td>
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<td>66.19</td>
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<td>57.44</td>
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<td>65.54</td>
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<td>57.64</td>
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<td>56.42</td>
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<td>44.94</td>
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<td>10.91</td>
<td>27.1</td>
<td>40.26</td>
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<td>28.4</td>
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<td>19.58</td>
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<td>8.57</td>
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</table>

Note: *= Assuming 100% plant emergence and survival

Table 10 Potato field establishment, plant survival and days to maturity during the second season at Perkerra

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Mean % plant emergence</th>
<th>SE</th>
<th>Mean % plant survival</th>
<th>SE</th>
<th>Days to maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterling</td>
<td>72.99</td>
<td>7.955</td>
<td>64.56</td>
<td>7.114</td>
<td>117</td>
</tr>
<tr>
<td>Ngure</td>
<td>72.3</td>
<td>7.955</td>
<td>76.37</td>
<td>7.114</td>
<td>117</td>
</tr>
<tr>
<td>Kenya Baraka</td>
<td>60.5</td>
<td>7.955</td>
<td>74.81</td>
<td>7.114</td>
<td>100</td>
</tr>
<tr>
<td>Pimpernel</td>
<td>60.22</td>
<td>7.955</td>
<td>81.05</td>
<td>7.114</td>
<td>100</td>
</tr>
<tr>
<td>Romano</td>
<td>60.07</td>
<td>7.955</td>
<td>94.2</td>
<td>7.114</td>
<td>100</td>
</tr>
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<td>Kenya Mavuno</td>
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<td>7.955</td>
<td>86.68</td>
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<td>100</td>
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<td>7.955</td>
<td>92.04</td>
<td>7.114</td>
<td>100</td>
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<td>7.955</td>
<td>82.7</td>
<td>7.114</td>
<td>100</td>
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<td>7.955</td>
<td>88.9</td>
<td>7.114</td>
<td>100</td>
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<td>7.955</td>
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<td>7.114</td>
<td>100</td>
</tr>
<tr>
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<td>7.955</td>
<td>84.58</td>
<td>7.114</td>
<td>100</td>
</tr>
<tr>
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<td>7.955</td>
<td>67.19</td>
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<tr>
<td>Meru Mugaruro</td>
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<td>69.76</td>
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<td>117</td>
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<td><strong>8.07</strong></td>
<td><strong>79.22</strong></td>
<td><strong>7.21</strong></td>
<td><strong>100.24</strong></td>
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</table>
Meru Mugaruro (Table 11). The mean yields were almost half of the yields realised during the first season (Table 8).

Table 11 Total yields (ton/ha) and % ware sized tubers harvested during the second season at Perkerra

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Total yields (ton/ha)</th>
<th>SE</th>
<th>% ware (60 mm ≤)</th>
<th>SE</th>
</tr>
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<td>7.989</td>
<td>2.697</td>
<td>57.62</td>
<td>10.78</td>
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<tr>
<td>Ngure</td>
<td>9.146</td>
<td>2.697</td>
<td>52.84</td>
<td>10.78</td>
</tr>
<tr>
<td>Kenya Baraka</td>
<td>6.819</td>
<td>2.697</td>
<td>73.48</td>
<td>10.78</td>
</tr>
<tr>
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<td>2.697</td>
<td>70.73</td>
<td>10.78</td>
</tr>
<tr>
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<td>11.766</td>
<td>2.697</td>
<td>70.25</td>
<td>10.78</td>
</tr>
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<td>2.697</td>
<td>69.76</td>
<td>10.78</td>
</tr>
<tr>
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<td>2.697</td>
<td>73.12</td>
<td>10.78</td>
</tr>
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<td>2.697</td>
<td>56.81</td>
<td>10.78</td>
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<tr>
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<td>2.697</td>
<td>61.5</td>
<td>10.78</td>
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<tr>
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<td>8.716</td>
<td>2.697</td>
<td>65.22</td>
<td>10.78</td>
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<td>2.697</td>
<td>59.84</td>
<td>10.78</td>
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<td>2.697</td>
<td>58.73</td>
<td>10.78</td>
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<td>2.697</td>
<td>62.72</td>
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<td>2.697</td>
<td>71.45</td>
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<td><strong>63.71</strong></td>
<td><strong>10.93</strong></td>
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</table>

About 40% of potential yields were realised at Perkerra during the second season (Table 12).

Table 12 Potential and realised yields during the second season at Perkerra

<table>
<thead>
<tr>
<th>Varieties</th>
<th>ton/ha</th>
<th>SE</th>
<th>*potential yields</th>
<th>SE</th>
<th>% potential yields realised</th>
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<td>2.697</td>
<td>18.05</td>
<td>4.905</td>
<td>44.26</td>
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<td>2.697</td>
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<td>56.63</td>
</tr>
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<td>44.48</td>
</tr>
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<td>2.697</td>
<td>21.64</td>
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<td>51.43</td>
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<td>2.697</td>
<td>20.71</td>
<td>4.905</td>
<td>56.81</td>
</tr>
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<td>2.697</td>
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<td>4.905</td>
<td>51.97</td>
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<td>4.905</td>
<td>50.59</td>
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<td>4.905</td>
<td>42.66</td>
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<td>30.23</td>
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<td><strong>4.97</strong></td>
<td><strong>41.61</strong></td>
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</table>

Note: *= Assuming 100% plant emergence and survival
There was a highly significant (P≤0.01) and positive correlation between total yields and plant survival at Mwea (Table 13).

Table 13 Correlations among total yields, plant emergence and plant survival at Mwea (upper diagonal) and at Bura (lower diagonal)

<table>
<thead>
<tr>
<th></th>
<th>Total yields (ton/ha)</th>
<th>Mean % plant emergence</th>
<th>Mean % plant survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total yields (ton/ha)</td>
<td>1</td>
<td>0.6334*</td>
<td>0.7723**</td>
</tr>
<tr>
<td>Mean % plant emergence</td>
<td>0.4627 ns</td>
<td>1</td>
<td>0.1544 ns</td>
</tr>
<tr>
<td>Mean % plant survival</td>
<td>0.6080*</td>
<td>0.2855 ns</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: **=significant at 0.01; *= significant at 0.05; ns= non significant

There was a highly significant (P≤0.01) and positive correlation between total yields and plant emergence at Perkerra during the first season (Table 14). All the other correlations were positive but non-significant.

Table 14 Correlations among total yields, plant emergence and plant survival at Perkerra during the first season (lower diagonal) and second season (upper diagonal)

<table>
<thead>
<tr>
<th></th>
<th>Total yields (ton/ha)</th>
<th>Mean % plant emergence</th>
<th>Mean % plant survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total yields (ton/ha)</td>
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<td>0.36 ns</td>
<td>0.1778 ns</td>
</tr>
<tr>
<td>Mean % plant emergence</td>
<td>0.726**</td>
<td>1</td>
<td>0.2293 ns</td>
</tr>
<tr>
<td>Mean % plant survival</td>
<td>0.3571 ns</td>
<td>0.4083 ns</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: **=significant at 0.01; *= significant at 0.05; ns= non significant

At all the sites, less than 50% of potential potato yields were realised. However, Mwea and Perkerra appear to be better sites for potato production than Bura in terms of realised and potential yields. Bura is hotter than the other two sites. The high temperatures at Bura could also be responsible for lack of ware-sized tubers. Temperature is the single most important uncontrollable factor affecting growth and yield of potato (Smith, 1968); above ground biomass and plant height is increased and tuber yield is reduced (Wolf et al., 1990). The shorter growth duration at Bura (65 days to maturity), which could have also be occasioned by high temperatures, could have further contributed to low yields.

In Mwea, the most productive varieties were Pimpernel (21.14), Shangi (19.71), Romano (19.6), Desiree (18.74), Kenya Mavuno (17.54) and Ngure (17.4 ton/ha). These varieties could be recommended for production in Mwea. During the first season at Perkerra, the six most productive varieties were Asante (28.64), Dutch Robyn (27.46), Roslin Eburu (23.21), Kenya Mavuno (22.42), Pimpernel (22.92) and Roslin Bvumbwe (22.47 ton/ha). These varieties could be recommended for production at Perkerra. Adoption of a particular variety could be high if it meets local tastes and preferences as well as market demand in addition to high yield. The old varieties that were released in Kenya a long time ago such as Desiree, Romano, Pimpernel, Roslin Eburu and Roslin Bvumbwe performed well in Mwea and Perkerra. These varieties have been in cultivation for a long time and may have probably become more adapted to local agroclimatic conditions hence high yields.

The positive correlations between total yields and % plant emergence and between total yields and % plant survival means that the two traits are important determinants of yields. Lack of consistency in significance of above correlations could probably be due to differences in the study sites (environment), differences in genotypes used (Table 1) or the genotype x environment interactions.

Research shows that efficient irrigation management can increase marketable yield (Bradley and Jeffrey, 1997); proper irrigation management helps optimize yields, size distribution and quality of both seed- and consumption-grade tubers. Moisture stress (depending on the crop growth stage) can reduce tuber yields, produce misshapen tubers, and negatively affect processing quality. Water stress from tuber initiation until the end of tuber bulking stage is the most detrimental to potato yields (Steyn et al., 2007).

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