1 Introduction

South Africa annually produces around 60,000 tons of sweet potato (DAFF 2014), a much lower production than most other countries in sub-Saharan Africa (FAOSTAT 2014). Notwithstanding, sweet potato is an important indigenized root crop in South Africa and a popular traditional crop in the northern subtropical regions of the country (Laurie et al. 2015b). The sweet potato industry in South Africa is notably different as there is, on one end, a small number of large commercial mechanized farmers and, on the other end, the crop features prominently in smallholder cropping systems delivering to the informal markets. Smallholder and subsistence farmers easily include sweet potato in their cropping programmes because of its versatility, ease to cultivate and hardiness. Additionally, many people are starting to note the value of orange cultivars as rich sources of provitamin A (Laurie et al. 2015b). This is of great importance since Vitamin A deficiency (VAD) in South Africa is a national public health problem with 43.6% of one- to nine-year-olds being vitamin A deficient (Shisana et al. 2013). The same survey also indicated that food security is at an unfavourable level, with 28.3% of the population at risk of hunger and 26.0% already experience hunger. Based on these alarming statistics, sweet potato is promoted for food and nutrition security. While the estimated informal market of 25,000 – 30,000 t for sweet potato brings an opportunity for income generation and enterprise development, there is a large potential for processing sweet potato into various products, such as biscuits, doughnuts, juice and chips that can be processed on kitchen-scale (Laurie et al. 2015b, but may be scaled to commercial size with higher sweet potato production.

Since 1995, the ARC-VOP breeding programme has been focussing on high yield, good root quality, adaptability, high dry mass and sweet taste. Furthermore, in 2003, β-carotene became the major breeding goal of the programme. Cultivars released include Ndou and Monate (2003), Bophelo (2011), and Mvuvhelo (2013), while a line from the International Potato Centre...
(CIP), 199062.1, is being promoted since 2010 (Laurie et al. 2015a,c). Trials at five research stations across 2008/9 to 2010/11 achieved total yield of 29.5 – 36.2 t/ha (mean 33.5 t/ha) and 17.3 – 24.6 t/ha (mean 20.0 t/ha) for marketable yield. However, the cultivars needed to be tested in a wider range of sites at on-farm conditions to confirm performance and for cultivar recommendations.

Farmers are basically interested in cultivars with consistent superior performance on their own farms, and those specifically adapted to farmer conditions and needs, with a high degree of stability over time Ceccarelli 1989). However, there are specific advantages with varieties that are input-responsive as these may be able to respond to changes in the environment in contrast to stable/non-responsive varieties. Popular multivariate approaches to investigate stability include the Tai stability test (Tai, 1971), Additive Main Effects and Multiplicative Interaction (AMMI) model (Gauch and Zobel 1996) and GGE (genotype main effect plus G x E interaction) biplot model, which simultaneously represents both mean performance and stability (Yan and Kang 2003), and variance components (Tumwegamire et al. 2016). In addition, there is potential in using additional statistical methods (e.g. Principal Component Analysis - PCA) to demonstrate association of variables and cultivars and Discriminant Analysis (DA) to determine the most prominent cultivar characteristics (Rencher, 2002).

Across the 2011/12 to 2014/15, commercially released cultivars for the informal market were evaluated under on-farm conditions and various agro-ecologies to identify those that perform well under farmer conditions and at different sites and, thus, can be widely recommended. This paper reports on the performance of released cultivars in on-farm trials in four provinces, their adaptability and stability, trait association and progress with vine distribution of the cultivars. The secondary purpose of the on-farm trials was to expose farmers to the improved cultivars and thereby extend production.

2 Methodology

2.1 Sites

On-farm trials were conducted in four provinces; nine locations in Kwa Zulu-Natal, four in Gauteng, one in the Eastern Cape province and one in Limpopo province. The experiments were conducted across the 2011/12 to 2014/15 planting seasons, one trial per site. The location information is presented in Table 1 and were representative of two regions, namely cool subtropical and warm temperate.

2.2 Planting material and trial maintenance

Six cultivars, as indicated in Table 2, were tested in a RCBD with three replicates at all 15 locations. Sweet potato cuttings were planted 30 cm apart in-row and 1 m apart intra-row. Plot size varied from 30 to 40 plants/plot depending on availability of cuttings. All plants were used for data collection. Cuttings were produced in a field multiplication block at the ARC-VOP which was established with source material from the sweet potato disease-tested scheme. Fertilizer mix (500 kg/ha 2:3:4 N,P,K) was broadcast before planting due to the low nutrient status generally found in resource-poor farmer sites. Fertilizer application was, however, half of the recommended dosage (Niederwieser, 2004) since farmers seldom afford to apply more. Supplementary irrigation was applied during the growing season for five to six months at each site (Table 1).

2.3 Data collection

Data collection included rating of storage root defects such as veins, constrictions, grooves (where on a 5-point ordinal scale, 1=very bad, 5=very few), marketable storage root yield (good quality roots between 100 and 1200 g) and unmarketable storage root yield classes (cracked, insect damaged, long irregular, <100 g, >1200 g, mechanical damaged, rotten). Two medium storage roots (250 to 500 g) were sampled for determination of dry mass (dried in oven at 70°C for 48 hours). Taste acceptability of 3 to 4 cooked storage roots was determined with small informal panels, using a rating scale: 1=excellent to 5=very bad.

2.4 Statistical analysis

A combined analysis of variance was performed using SAS 9.4 (SAS Institute Inc., Cary, North Carolina) with sources: cultivar, location and region and their interaction (John and Quenouille 1977). The Additive Main Effects and the Multiplicative Interaction (AMMI) model was used to analyse genotype by environment interaction using Gen Stat Release 15.2 (VSN International Ltd., Hemel, Hempstead) for cultivar * location. “Year” was not a variable because the trials were not repeated per location (Gauch et al. 2008). Principal component analysis was performed to demonstrate association of variables (Loadings) and cultivars (Scores) with PCA Factor scores. A discriminant analysis (using XLSTAT 2013 (Addinsoft, Paris, France) was done to determine the most prominent cultivar characteristics (Rencher 2002).
| Region            | Loc Code | Location name   | Location details                     | Province          | Planting & Harvest date | Altitude (m) | Mean Max °C January | Mean Max °C June | Mean Min °C July | Mean annual rain mm | Mean rain months of trial mm |
|-------------------|----------|-----------------|--------------------------------------|-------------------|-------------------------|---------------|---------------------|-------------------|----------------|---------------------|-----------------------------|
| Cool subtropical  | BUL      | Nongoma 1       | Bululwane - Nongoma 2012/13          | KwaZulu-Natal     | 29/10/2012-30/03/2013   | 367           | 29.9                | 21.9              | 7.4            | 775                 | 548                         |
|                   | MLA      | Ulundi 1        | Mhlabatini - Ulundi 2012/13          | KwaZulu-Natal     | 30/10/2012-27/03/2013   | 522           | 28.9                | 21.9              | 7.5            | 685                 | 481                         |
|                   | MAYE     | Nongoma 2       | Maye – Nongoma/Hlabisa 2014/15       | KwaZulu-Natal     | 29/10/2014-26/03/2014   | 337           | 29.9                | 21.9              | 7.4            | 775                 | 548                         |
|                   | CEZ      | Ulundi 2        | Ceza 1 Nongoma 2014/15               | KwaZulu-Natal     | 10/12/2014-20/05/2015   | 353           | 29.9                | 21.9              | 7.4            | 775                 | 500                         |
|                   | PON      | Pongola         | Khiphunyawa - Piet Retief 2013/14    | KwaZulu-Natal     | 05/12/2013-13/05/2014   | 830           | 28.7                | 21.7              | 7              | 632                 | 447                         |
| Warm temperate    | NEB      | Nebo            | Mamphokgo - Nebo 2014/15            | Limpopo           | 24/11/2014-19/05/2015   | 945           | 28.2                | 21.2              | 6              | 670                 | 474                         |
|                   | DUM      | Paulpietersburg | Dumbe - Paulpietersburg 2014/15     | KwaZulu-Natal     | 09/12/2014-27/05/2015   | 1144          | 27.3                | 20.2              | 4.1            | 746                 | 463                         |
|                   | KUT      | Soshangueve     | Kutlwano - Soshangueve 2011/12      | Gauteng           | 18/01/2012-8/06/2012    | 1179          | 28.7                | 19.5              | 4             | 686                 | 371                         |
|                   | SIM      | Ekangala 2      | Simajo - Bronkhorstspruit 2011/12   | Gauteng           | 20/01/2012-18/06/2012   | 1375          | 26.7                | 17.8              | 1.6            | 570                 | 263                         |
|                   | WIN      | Winterveldt     | Winterveldt 2011/12                 | Gauteng           | 19/01/2012-11/06/2012   | 1101          | 29                  | 20                | 4             | 685                 | 370                         |
|                   | SYA      | Ekangala 1      | Siyathuthuka - Bronkhorstspruit 2011/12 | Gauteng       | 21/01/2012-20/06/2012   | 1375          | 26.7                | 17.8              | 1.6            | 570                 | 263                         |
|                   | MON      | Vryheid 1       | Vryheid Mondlo 2013/14              | KwaZulu-Natal     | 03/12/2013-14/05/2014   | 1150          | 26.4                | 19.6              | 3.5            | 688                 | 359                         |
|                   | MVU      | Vryheid 2       | Vryheid Mvunyane 2013/14            | KwaZulu-Natal     | 04/12/2013-08/04/2014   | 1040          | 26.4                | 19.6              | 3.5            | 688                 | 559                         |
|                   | MAP      | Ladysmith       | Mphophomeni Ladysmith 2014/15       | KwaZulu-Natal     | 24/10/2014-24/04/2015   | 1023          | 28.1                | 20                | 2.5            | 639                 | 481                         |
|                   | MJI      | Kokstad         | Mjila - Kokstad 2012/13             | Eastern Cape      | 28/11/2012-26/05/2013   | 1319          | 25.5                | 18                | 1              | 620                 | 439                         |
| Cultivar | Origin | Yield | Skin colour | Flesh color | Storage root shape | β-carotene (mg/100g fwb) | Dry matter | Maturity period: Early (± 4.5 months), medium to late (± 5 months) | Resistance to SPFMV | Resistance to Alternaria blight | Resistance to Fusarium wilt | Resistance to nematodes (Meloidogyne sp.) |
|----------|--------|-------|-------------|-------------|--------------------|--------------------------|------------|------------------------------------------------|------------------|-----------------------------|-----------------------------|----------------------------------|
| 199062.1 | CIP    | High  | Cream pale orange | Yellow orange | Heavy oblong – irregular | 2.10 | Medium | Early | S | R | R | MR |
| Ndou     | ARC    | High  | Cream – slight pale orange | Cream–cream, pale orange Cream | Round elliptic to Long obovate | 0.21 | High | Medium | S | R | MR | MR |
| Monate   | ARC    | High  | Cream, purple tip Cream | Cream | Long elliptic to Round elliptic | 0.02 | High | Early | S | R | MS | R |
| Mvuhelo  | ARC    | High  | Cream-white Pale cream | Pale cream | Round | 0.01 | High | Early | S | R | MR | R |
| Bophelo  | ARC    | Medium-high Orange | Orange | Round elliptic to long elliptic | 6.71 | Medium | Medium | S | R | MR | MR |
| Impilo   | ARC    | Medium Yellow orange | Pale orange | Round elliptic to Elliptic | 5.09 | Medium | Medium | S | R | R | MS |

ARC = Agricultural Research Council, South Africa, CIP = International Potato Centre, N/A = Not applicable, R = Resistant, S = Susceptible, M = Moderate

For resistance refer to: SPFMV - Domola et al. (2008), Alternaria – Kandolo et al. (2016), Fusarium wilt – Dau (2016), Nematodes – Pofu et al. (2016)
3 Results

3.1 Yield components

Significant effects were detected for location*cultivar and region*cultivar for total and marketable storage root yield, and for marketable yield only cultivar (Table 3). Unmarketable classes insect damage (%) and cracked (%) showed significant effects for locality, region and cultivar, and their interactions. The marketable yield (Table 4) of cultivars 199062.1 and Ndou were significantly higher than that of all the other cultivars, and the mean marketable yield over 15 locations was 15.8 t/ha. The mean total yield ranged from 24.8 to 28.5 t/ha (mean 26.8 t/ha).

Cultivar 199062.1 had significantly less insect-damaged roots than all other cultivars (Table 4). Ndou and 199062.1 had lower percentage cracked roots. The average marketable root weight was 242.2 g, which was significantly higher in cultivar 199062.1 than in other cultivars; therefore, indicative of larger storage roots. Ndou was shown to be high in dry mass with a good taste rating (Table 4). The most prevalent unmarketable class was insect-damaged roots (mean of 15.1%), predominantly caused by sweet potato weevil (Table 5). The mean marketable percentage was 59.1% (data not shown).

Table 3: Combined analysis of variance of a series of on-farm cultivar demonstration trials in 15 locations

| Source       | df  | ms     | pr>F | df  | ms     | pr>F | df  | ms     | pr>F |
|--------------|-----|--------|------|-----|--------|------|-----|--------|------|
| Locality     | 14  | 1297.1 | <0.001| 212.6 | <0.001| 742.5 | <0.001|
| Region       | 1   | 99.9   | 0.131| 691.7 | <0.001| 5427.0| <0.001|
| Rep(Local)   | 30  | 74.0   | 0.020| 27.0  | 0.389 | 184.1 | <0.001|
| Cultivar     | 5   | 80.4   | 0.106| 114.4 | <0.001| 502.1 | <0.001|
| Local x Cult | 70  | 79.8   | 0.001| 50.3  | <0.001| 75.8  | <0.001|
| Region x Cult| 5   | 208.5  | <0.001| 133.1 | <0.001| 143.2 | <0.001|
| Error        | 150 | 43.4   | 25.4 | 45.8  | 149   | 21.5  | <0.001|
| Total        | 269 |        |      |       |       |       |       |

df = Degrees of Freedom, ms = Mean Squares and pr = Probability of F

Table 4: Mean storage root yield performance for six cultivars over 15 on-farm sites in South Africa

| Cultivars    | Total root yield (t/ha) | Marketable root yield (t/ha) | Average marketable root weight (g) | Insect damaged roots % | Cracked roots % | Dry mass % | Taste rating** |
|--------------|-------------------------|-----------------------------|-----------------------------------|------------------------|----------------|-----------|---------------|
| 199062.1     | 28.5                    | 19.0a                       | 304.5a                            | 9.9d                   | 1.8c           | 26.39     | 2.60          |
| Ndou         | 27.8                    | 17.8a                       | 256.6b                            | 14.1bc                 | 1.4c           | 29.29     | 2.14          |
| Monate       | 27.2                    | 15.8b                       | 242.4b                            | 18.1a                  | 2.5bc          | 26.44     | 2.65          |
| Mvuvhelo     | 25.9                    | 15.2bc                      | 206.3c                            | 14.0c                  | 4.5ab          | 26.28     | 2.31          |
| Bophelo      | 26.6                    | 13.8cd                      | 207.9c                            | 16.9ab                 | 5.3a           | 23.66     | 2.31          |
| Impilo       | 24.8                    | 13.1d                       | 203.6c                            | 18.9a                  | 4.2ab          | 21.41     | 2.85          |
| Pr > F       | 0.106                   | <.0001                      | <.0001                            | <.0001                 | <.0001         | na        | na            |
| CV           | 24.6%                   | 29.3%                       | 16.6%                             | na                     | na             | na        | na            |
| LSDp=0.05    | ns                      | 1.93                        | 16.39                             | 2.82                   | 2.10           | na        | na            |
| Overall Range| 3.8-61.5                | 1.4-49.6                    | 88-618.1                          | 0-81                   | 0-45.5         | 16.2-35.8 | 1.3-4.6       |

na = not applicable ns = not significant

*Mean from 12 locations (collection of replicated results were not possible at all sites; variable excluded in ANOVA)

**Rating scale: 1=Excellent; 5=Very bad; Mean of one rating at 15 sites (variable excluded in ANOVA)
3.2 Effect of region and location

As indicated, the trial locations were divided in two different climatic regions, warm temperate and cool subtropical. ANOVA (Table 3) showed the interaction of cultivar*region had significant effect on cultivar yield. Cultivar Muvhelo performed particularly well at Ulundi 1 (47.4 t/ha) and Ekangala 2 (44.0 t/ha), while having very low total yield at Ladysmith (8.1 t/ha), Nongoma 1 (10.5 t/ha) and Vryheid 1 (11.0 t/ha) (Fig. 1). Ekangala 2 (37.9 t/ha), Ulundi 1 (36.5 t/ha) and Soshanguve (36.1 t/ha) had the highest total yield, while at Nongoma 2 (10.1 t/ha), Vryheid 1 (14.1 t/ha) and Winterveldt (17. t/ha) had low mean total yield (Fig. 1). However, the factor region was not significant for total yield nor for marketable storage root yield (Table 3).

3.3 Genotype by environment interaction

The AMMI biplot of the first PCA versus marketable storage root yield explained 52.39% of the genotype by environment interaction (Fig. 2a). AMMI indicated a stable (PC1 score between 1.5 and -1.5) and high marketable yield for Ndou, while Monate had also stable although average marketable yield. The highest yielding cultivar 199062.1 as well as Muvhelo had unstable marketable yields; PC1 scores surpassing 2.5 and -2.5, respectively. The PC1 score of orange-fleshed cultivar Bophelo was just inside the cut-off line of being stable. This can be an advantage as the cultivar may have the potential to adapt to changes in conditions. Ndou performed well at environment sites Ulundi 2 (CEZ), Pongola (PON), Vryheid 2 (MON), Vryheid 2 (MVU), Kokstad (MJI), lying in their close proximity. A second grouping of similar sites were Nongoma 2 (MAYE), Ladysmith (MAP), Nebo (NEB) and Ekangala 2 (SIM). Bophelo was specifically adapted to Paulpietersburg (DUM) and 199062.1 to Ulundi 1 (MLA); Monate to Nongoma 1 (BUL); and Mvuvhelo and Impilo to Ekangala 1 (SYA).

Table 5: Mean values and range for unmarketable storage root classes, taste acceptability score and dry mass content over 15 on-farm locations in South Africa

| Class                          | Minimum | Maximum | Mean |
|--------------------------------|---------|---------|------|
| Insect damaged %               | 0       | 67.3    | 15.1 |
| Unmarketable small %           | 0       | 25.6    | 6.5  |
| Damaged %                      | 0       | 19.9    | 5.7  |
| Grooves %                      | 0       | 30.0    | 5.1  |
| Unmarketable large %           | 0       | 36.7    | 4.7  |
| Veins %                        | 0       | 55.0    | 4.3  |
| Constrictions %                | 0       | 20.0    | 3.6  |
| Cracked %                      | 0       | 26.3    | 2.9  |
| Rat damaged %                  | 0       | 36.2    | 2.8  |
| Rotten %                       | 0       | 13.7    | 1.8  |
| Curved %                       | 0       | 22.0    | 1.7  |
| Taste score*                   | 1.3     | 4.6     | 2.5  |
| Dry mass %                     | 16.2    | 35.8    | 25.5 |

*Rating scale: 1=Excellent; 5=Very bad

Figure 1: Locality by cultivar interaction means for total yield for six cultivars by 15 on-farm trials (localities)
In terms of total storage root yield (Fig. 2b), the AMMI biplot of the first principal component versus total yield explained 58.45% of the genotype by environment interaction. The AMMI analysis indicated stable total yield performance from Ndou and Monate (placed close to a zero PC1 score), while the other four cultivars had unstable performance (PC1 scores surpassing 2.5 and -2.5). Impilo cultivar performed well at environment sites SYA and Soshanguve (KUT). Monate and Ndou performed particularly well at MON, while cultivars 199062.1 and Bophelo performed better at MLA.

The AMMI graph insect (mostly weevil) damage percentage presented in Figure 3a revealed that the first principal component explained 59.02% of the genotype by environment interaction. The highest insect (mostly weevil) damage % was detected for Impilo. The cultivar was stable with regards to this negative trait (PC1 score -1.25). Monate, Mvuhelo and Bophelo had medium high insect damage but unstable in this regard, while Ndou was stable, lying close to the zero line. The lowest weevil damage was observed for 199062.1 cultivar. A mega-environment (group of similar environments) was seen for KUT, Winterveld (WIN), SIM, MJI, MON, CEZ, DUM and MVU associating with Ndou and 199062.1 cultivars.

The AMMI biplot of the first principal component versus cracked roots percentage explained 58.45% of

Figure 2: Biplot of IPCA1 versus a) mean marketable storage root yield and b) total storage root yield for six sweet potato cultivars evaluated over 15 sites (Site abbreviations are explained in Table 1) (The cut-off line for stability is indicated in perforated blue line).
the genotype by environment interaction (Fig. 3b). Bophelo, Mvuvhelo and Impilo had high mean cracked root percentage. Impilo and Ndou was stable (PC1 score between 1.5 and -1.5) and the other four cultivars were unstable. Environments reacting similarly included WIN, MAP, KUT, MVU, DUM, PON, NEB, MON and BUL forming a mega-environment with Ndou cultivar, which had the lowest cracked percentage. Monate and 199062.1 cultivars were associated with MJL, whereas Bophelo cultivar associated with SYA and CEZ sites.

### 3.4 Cultivar association and predominant traits of cultivars

The discriminant analysis divided the cultivars into three groups (Fig. 4a), of which the grouping was mostly based on veins (%), dry mass% and average root mass. The three cream-fleshed, dry cultivars Ndou, Monate and Mvuvhelo grouped together in the top right quadrant, whereas the orange-fleshed cultivars Bophelo and Impilo are in the bottom right quadrant medium dry mass percentages).
The yellow-orange cultivar 199062.1 was separated from all other cultivars and tended to produce many storage roots with the defect veins.

The results of the PCA biplot showed that the characteristics curved (%), veins, damaged (%), grooves and dry mass (%), those displayed furthest away from the centre, were most important to distinguish the cultivars (Fig. 4b). The PCA further demonstrates the association of variables (loadings) and cultivars (scores) with PCA factor scores in terms of quality traits of cultivars. Figure 4b shows that Ndou has high % marketable roots and high dry mass; therefore, it is a cultivar with good root quality. However, Ndou may also show some grooves on its roots. Monate and Mvuhelvo cultivars, despite their good yielding ability, tend to have high root-infestation by weevil and some rotten roots. The 199062.1 cultivar produced a high total yield but the large-sized roots showed several defects such as veins, curved and damaged roots. Orange-fleshed cultivars bear more unmarketable small roots (<100g), and tend to have cracked, rat-damaged and insect-infested roots.

4 Discussion

In the present study, an overall mean total yield of 15.8 t/ha was measured for the six sweet potato cultivars in the on-farm trials at 15 sites. A mean total storage root yield of 15.3 t/ha was observed for 10 sweet potato cultivars evaluated by Tumwegamire et al. (2016). In a study by Andrade et al. (2016), cultivar 199062.1 achieved a total yield of 15.3 t/ha over a three-year period at Umbeluzi, Mozambique. The mean yield observed in the present study is slightly higher than the mean marketable yield of 13.5 t/ha achieved by informal market cultivars grown by four farmers in Limpopo Province in sweet potato enterprise establishment projects. The results of this study are comparable to farmers’ yield and present representative sites for selection of cultivars for this level of farmers. However, the factor region was not significant for total yield nor for marketable storage root yield (Table 3). Thus, the differences in cultivar performance need to be explained in follow-up experiments by other factors; possibly water application, management, and soil conditions.

An alternative way of evaluating genotype by environment interaction is by using variance components as demonstrated by Tumwegamire et al. (2016). Furthermore, Yan et al. (2015) developed a function to calculate the optimum number of locations. Results of the present study showed wide variations for locations for both total and marketable root yields (Figs. 2a and 2b). Cracked and insect-damaged percentage (predominantly caused by weevil) showed pertinent similar performance at various locations (Figs. 3a and 3b). These traits formed mega-environments and, consequently, require fewer environment sites to make recommendations. The significant environment effects on root yield are consistent with previous studies (Tumwegamire et al. 2016, Mcharo and Ndolo 2013). As expected, cultivar Ndou performed well under farmer conditions over several sites; thus, it...
can be widely recommended for farmer use. Furthermore, a performance index can be calculated to recommend cultivars per site using various traits and ranking each as equally important if data from two years of evaluation per location is available (Lehmann and D’Abrera 2006).

A nursery foundation block established at ARC-VOP from disease-tested planting material of the evaluated cultivars, during February to April 2016 disseminated vines to nine vine grower enterprises in five provinces. In total 2.1 million cuttings from 10 nurseries were disseminated to farmers (3868 bags of vines), whereas a total of 3885 bags were disseminated in 2014/15 (Table 6). The amount of vine dissemination in 2015/16 was negligible due to severe drought in those years. The area planted during 2016/17 season was 86 ha, of which 59% were orange-fleshed sweet potato – almost all from Bophelo cultivar. The fresh produce was delivered to the informal markets in the various areas. Bophelo was the dominant orange-fleshed cultivar, while Ndou topped the cream-fleshed informal market cultivars (Table 6). The dissemination of vines is a continuation of projects that were initiated in 2010 and 2013 (Laurie et al. 2015b).

5 Conclusions

Over the past three planting seasons, there has been a considerable increase in availability of vines and fresh produce of the informal market cultivars. The cultivars have a large potential for income generation. The present findings need to be further validated using multi-location and multi-season data to confirm repeatability and for future recommendation of the cultivars. Principle component analysis and discriminative analysis were found to be quick analytical tools to associate quality traits with cultivars to ease cultivar recommendations in conjunction with ranking.

The present study indicated that a mean marketable yield of 15.8 t/ha was achieved in on-farm trials, and that cultivar 199062.1, followed by Ndou had the highest marketable yields. The best orange-fleshed cultivar in terms of uptake by farmers was Bophelo, with slight advantage with regards to yield and yield stability, dry mass (%) and taste over Impilo cultivar. Ndou also produced stable high total as well as marketable yield over 15 environment sites. The most prevalent unmarketable root yield class was weevil infestation. Veins, dry mass and mean marketable root mass were the main variables that made cultivars distinguishable. The improved sweet potato cultivars produce sustainable yields and, therefore, have a large commercial potential to generate income for producers to sell in the informal markets. This study is also significant because it confirmed the cultivar Bophelo as the best orange-fleshed cultivar to address vitamin A deficiency in South Africa.

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| Type of cultivar                              | Cultivar name | 2016/17 | 2014/15 |
|-----------------------------------------------|---------------|---------|---------|
| Commercial cream-fleshed                      | Blesbok       | 413     | 727     |
| Orange-fleshed, medium dry for informal marketing | Bophelo     | 1942    | 1933    |
|                                               | Impilo        | 164     | 126     |
| Cream, dry taste for informal marketing       | Ndou          | 335     | 834     |
|                                               | Monate        | 546     | 203     |
|                                               | Mvuvhelo      | 10      | 51      |
|                                               | 199062.1      | 282     | N/A     |
| Other                                         |               | 176     | N/A     |
| TOTAL                                         |               | 3868    | 3885    |

N/A = Not applicable
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