Research Article

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Breeding farmer and consumer preferred sweetpotatoes using accelerated breeding scheme and mother–baby trials

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Abstract: Increased sweetpotato utilization has become an important breeding objective recently, with much emphasis on the development of non-sweet sweetpotatoes for income and food security in Ghana. The objective of this study was to evaluate 26 elite non-sweet and less sweet sweetpotato genotypes with regard to their release as commercial varieties using mother–baby trial. The 26 sweetpotato genotypes were tested multilocal on-farm across five ecozones from 2016 to 2017. These genotypes were selected from accelerated breeding scheme carried out from 2010 to 2013. There were no year-by-ecozone-by-genotype and year-by-ecozone interactions. However, ecozone-by-genotype interaction was significant for storage root dry matter, beta-carotene, iron and zinc content. This implies that the relative performance of the genotypes for storage root yield was stable across locations and years. Genotypic differences were found for all the traits and indicated that selection of superior genotypes across ecozone was possible. Storage root yield ranged from 7 t/ha to 39 t/ha, while dry matter content ranged from 34% to 46%. The storage root cooking quality preference was comparable with farmers' check. Ten superior genotypes were identified for release as commercial varieties based on their staple-preferred taste, higher storage root yield, higher dry matter content, earliness, resistance to the sweetpotato virus, sweetpotato weevil and *Alcidodes*.

1 Introduction

Sweetpotato (*Ipomoea batatas* L. (Lam)) belongs to the botanical family Convolvulaceae (Thottappilly 2009) and is among the few crop plants of major economic importance in the family use for food globally (Eich 2008), which may be due to the *Agrobacterium* infection which occurred in its evolution (Kyndta et al. 2015). The potential of sweetpotato in food security and global well-being has been reported (Van Hal 2000; Bouvelle-Benjamin 2007; Low et al. 2009; Betty 2011; Health Research Staff 2012; Jacobi 2013; Oliver 2015; Eating Well 2019). It is the fourth most important root and tuber crop in Ghana in terms of production (Baafi et al. 2016c). Its annual production is estimated at 1,35,000 tonnes, representing just under 0.6% of root and tuber crops produced in Ghana (FAOSTAT 2013).

Improved high-yielding crop varieties stimulate transition from low-productivity subsistence agriculture to a high-productivity agro-industrial economy (Just and Zilberman 1988; Asfaw et al. 2012; Mackill and Khush 2018; Voss-Fels et al. 2019). Sweetpotato has remained an untapped resource in Ghana despite giant strides made in releasing high yielding varieties (Adu-Kwarteng et al. 2001; Ellis et al. 2001; Adu-Kwarteng et al. 2002; Meludu et al. 2003; Zuraida 2003; Baafi 2014). The decision to adopt a new cultivar is complexly related to field and yield performance as well as consumer taste acceptability (Sugri et al. 2012). Consumer preference is critical in determining the suitability of sweetpotato to any locality (Tomlins et al. 2004; Kwach et al. 2010). It is reported that some cultivars were not adopted because of lack of sufficient consideration of farmers' and consumers' preference (Toomey 1999; Banziger and Cooper 2001; Derera et al. 2006). Effective breeding

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should be based on clear identification of stakeholders' constraints and preferences (Adesina and Zinnah 1993; Sal et al. 2000; Baafi et al. 2015b). Consumers in Ghana prefer non-sweet sweetpotatoes with high dry matter content (Sam and Dapaah 2009; Baafi 2014; Baafi et al. 2015b). Locally available sweetpotatoes have very sweet taste, limiting their consumption as a staple food (Missah and Kissiedu 1994). Orange-fleshed sweetpotatoes were introduced to combat vitamin A deficiency at relatively cheaper cost but they have low dry matter content (Baafi 2014). High dry matter is one of the important attributes that affects consumer preference in most of sub-Saharan Africa (Tumwegamire et al. 2004). Development of end-user preferred sweetpotatoes has become key objective in sweetpotato breeding in Ghana (Baafi et al. 2016c) as higher yield is important in crop breeding (Rausul et al. 2002).

Successful development and release of staple-type sweetpotatoes requires accelerated breeding scheme (ABS) (Grüneberg et al. 2004) and mother–baby trial approach. The advantage of ABS is that each botanical seed of sweetpotato is a potential variety, and once the seeds rapidly multiply, multilocal field testing, which allows faster selection of promising varieties, takes place. A key part of on-farm trials is to conduct experiment on farmers' fields under farmers' conditions (John 1997). This creates opportunities for farmers to participate in the evaluation of varieties under their production environments. However, in larger breeding programmes, where the output of ABS results in a larger number of promising varieties, mother–baby trial approach, which allows quantitative data from researcher managed mother trials to be systematically cross-checked with farmer-managed baby trials with similar themes (Kamanga et al. 2001), is recommended (Mutsaers et al. 1997; Fielding and Riley 1998).

A key requirement and the final step in the development and release of improved crop varieties in Ghana involves at least two seasons, multilocal on-farm evaluation. The objective of this study was to evaluate 26 elite non-sweet and less sweet sweetpotato varieties developed through ABS on-farm with regard to their release as commercial varieties using mother–baby trial.

2 Materials and methods

The breeding work began with a survey aimed at identifying constraints and breeding priorities that will

facilitate increased sweetpotato utilization in Ghana in 2011 (Baafi 2014; Baafi et al. 2015b). Concurrently, genetic potential of the collected germplasm was exploited to identify the useful genetic variation for the development of non-sweet sweetpotatoes from 2011 to 2012 (Baafi 2014; Baafi et al. 2015a; 2016d). This was followed by hybridization of parental genotypes selected in 2012 and on-station multilocal evaluation of F_1 progenies in 2013 (Baafi 2014; Baafi et al. 2016a; 2016b; Baafi et al. 2017). Twenty-six elite F_1 s selected were tested multilocal on-farm in 2016 and 2017 using mother–baby trial approach. The 26 genotypes were divided into five groups, each subset having five genotypes (except group 2, which had six; Table 1). The trials were established in the major sweetpotato growing areas in the five ecozones of Ghana (Table 2). Six farmers were selected at each ecozone in collaboration with the Ministry of Food and Agriculture staff. Five farmers were given a subset each for planting (baby trial). The sixth farmer planted all the 26 genotypes

Table 1: The 26 F_1 s selected from the ABS and used for the multilocal on-farm evaluation using mother–baby trial approach

Group	Genotype*	Field I.D.
GP 1	82 × 87–13	AGRA SP 25
	61 × 87–1	AGRA SP 01
	87 × 61–88	AGRA SP 11
	79 × 82–4	AGRA SP 21
	82 × 50–21	AGRA SP 22
GP 2	82 × 87–11	AGRA SP 24
	87 × 61–24	AGRA SP 07
	87 × 61–21	AGRA SP 06
	79 × 82–3	AGRA SP 20
	79 × 21–8	AGRA SP 13
GP 3	79 × 50–10	AGRA SP 27
	61 × 87–15	AGRA SP 02
	87 × 61–58	AGRA SP 09
	87 × 61–13	AGRA SP 04
	79 × 50–4	AGRA SP 15
GP 4	79 × 50–12	AGRA SP 19
	87 × 61–3	AGRA SP 03
	87 × 61–16	AGRA SP 05
	87 × 61–11	AGRA SP 12
	79 × 50–8	AGRA SP 17
GP 5	82 × 50–32	AGRA SP 23
	82 × 61–27	AGRA SP 08
	87 × 61–65	AGRA SP 10
	79 × 50–6	AGRA SP 16
	82 × 79–1	AGRA SP 26
	79 × 50–9	AGRA SP 18

*61 = Ogyefo; 81 = Histarch; 50 = Apomuden; 82 = Beauregard; 79 = CIP 443035; 21 = Resisto.

Table 2: Study areas for the multilocal on-farm evaluation

Municipal/District	Region	Ecozone
Techiman South	Brong Ahafo	Transition
Ejura-Sekyeredumase	Ashanti	Transition
Offinso North	Ashanti	Forest
Fanteakwa	Eastern	Forest
Upper West Akim	Eastern	Forest
Komenda-Edina-Eguafo-Abrem	Central	Coastal savannah
Cape coast	Central	Coastal savannah
Gomoa East	Central	Forest
Abura-Asebu-Kwamankese	Central	Coastal savannah
South Tongu	Volta region	Coastal savannah
Central Tongu	Volta region	Coastal savannah
Akatsi South	Volta region	Coastal savannah
Ketu North	Volta region	Coastal savannah
Tolon	Northern	Guinea savannah
Savelugu/Nanton	Northern	Guinea savannah
Kumbugu	Northern	Guinea savannah
Mion	Northern	Guinea savannah
Wa West	Upper West	Guinea savannah
Nandowli-Kaleo	Upper West	Guinea savannah
Jirapa	Upper West	Guinea savannah
Lawra	Upper West	Guinea savannah
Nandom	Upper West	Guinea savannah
Kassena Nankana	Upper East	Guinea savannah
Nabdam	Upper East	Guinea savannah
Binduri	Upper East	Guinea savannah
Pusiga	Upper East	Guinea savannah

(mother trial). Each farmer used the best-bet variety as check. Planting was on ridges at spacing of 1×0.3 m, giving a plant population density of 33,333 plants per hectare. Harvesting was at four months after planting, and the plants on the two central ridges were used for data taking, excluding the plants at the ends.

2.1 Data collection

Twenty plants were harvested per plot for data collection. Storage roots considered were as reported by Ekanayake *et al.* (1990). The physicochemical traits determined were beta-carotene, total sugars, starch, iron, and zinc content using the near-infrared reflectance spectroscopy (NIRS) (Tumwegamire *et al.* 2011). Dry matter content was calculated as the ratio of the weight of the dry sample expressed as a percentage of the weight of the fresh sample. In addition, the incidence and severity of diseases and pests (sweetpotato virus disease, sweetpotato weevil and *Alcidodes*) were scored on a scale of 1–5, where 1 – no disease/damage; 2 – minimum; 3 – average; 4 – high; and 5 – all plants affected. Incidence indicates the percentage of plants affected by disease or pest. At harvest of

the mother trials, field days were organized for farmers to assess the vegetative part and the storage root yields as well as the cooking quality of the genotypes compared with their best-bet variety.

2.2 Data analysis

Data for 18 out of the 26 genotypes were analysed due to missing information alongside farmers' variety. The analysis excluded data on AGRA SP 02, AGRA SP 03, AGRA SP 10, AGRA SP 15, AGRA SP 18, AGRA SP 21, AGRA SP 22 and AGRA SP 26. The data were analysed using split-split plot design (YEAR = main plot; ECOZONE = sub-plot; GENOTYPE = sub-sub-plot). The data on the sensory evaluation were presented graphically.

3 Results

There were no year-by-ecozone-by-genotype interaction ($Y \times E \times G$) and year-by-ecozone interaction ($Y \times E$) for

Table 3: Mean squares for storage root yield and quality traits of the 26 sweetpotato genotypes

Source of variation	Df	Storage root dry matter	Beta-carotene content	Starch content	Sugar content	Iron content	Zinc content	Storage root yield
Rep	1	1016.01	481.05	34.81	215.71	1.35	0.29	797.50
Year (Y)	1	5.45 ^{ns}	977.22 ^{ns}	111.11 ^{ns}	74.83 ^{ns}	0.37 ^{ns}	0.70 ^{ns}	1749.90 ^{ns}
Error	1	467.77	121.17	134.28	779.10	0.14	0.02	598.00
Ecozone (E)	3	380.97 ^{ns}	264.02 ^{ns}	242.63 ^{ns}	473.91 ^{ns}	1.11 ^{ns}	0.84 ^{ns}	1128.00 ^{ns}
Y × E	3	91.35 ^{ns}	382.00 ^{ns}	15.25 ^{ns}	120.88 ^{ns}	0.23 ^{ns}	0.07 ^{ns}	2957.90 ^{ns}
Error	6	75.89	180.31	79.83	143.73	0.58	0.18	2501.00
Genotype (G)	18	258.74 ^{**}	682.70 ^{**}	187.19 ^{**}	22.78 ^{**}	0.89 ^{**}	0.51 ^{**}	891.0 ^{**}
Y × G	18	17.20 ^{ns}	38.94 ^{ns}	14.95 ^{ns}	6.24 ^{ns}	0.08 ^{ns}	0.02 ^{ns}	142.00 ^{ns}
E × G	54	17.95 [*]	73.12 ^{**}	21.78 ^{ns}	6.44 ^{ns}	0.10 ^{**}	0.05 ^{**}	164.00 ^{ns}
Y × E × G	54	9.85 ^{ns}	30.71 ^{ns}	23.50 ^{ns}	3.82 ^{ns}	0.05 ^{ns}	0.02 ^{ns}	146.60 ^{ns}
Error	144	11.17	7.40	27.33	5.64	0.05	0.02	155.70
CV (%)		8.3	37.5	7.0	15.0	13.8	16.4	68.1

*Significant at $p < 0.05$; **Significant $p < 0.01$; ^{ns}not significant.

all the traits (Table 3). However, ecozone-by-genotype ($E \times G$) was significant ($p < 0.05$) for storage root dry matter, beta-carotene, iron, and zinc content. Genotypic differences were significant ($p < 0.05$) for all the traits. AGRA SP 13 had the highest storage root yield (39.20 t/ha) across ecozones over two years, while AGRA SP 16 was the lowest (7.39 t/ha) (Table 4). Eleven genotypes

had comparable yield across ecozones over two years as the farmers' check (Table 4). AGRA SP 16 and AGRA SP 12 had the lowest (34.32%) and the highest (45.53%) storage root dry matter content across ecozones over two years (Table 5). In all, 13 genotypes had comparable dry matter content as the farmers check across ecozones over two years (Table 5). All the genotypes were resistant to

Table 4: Storage root yield (t/ha) of the sweetpotato genotypes across ecozones over two years

Genotype	Ecozone												Grand mean
	Coastal savannah			Forest			Guinea savannah			Transition			
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	
AGRA SP 01	11.94	25.28	18.61	8.23	8.06	8.19	29.72	18.61	24.17	0.39	38.06	19.22	17.55
AGRA SP 04	18.33	21.94	20.14	20.56	14.17	17.36	15.00	14.17	14.58	13.33	49.72	31.53	20.90
AGRA SP 05	20.00	15.00	17.50	10.28	17.22	13.75	16.67	11.39	14.03	11.39	43.61	27.25	18.19
AGRA SP 06	12.00	16.94	14.47	12.44	14.89	13.67	33.33	19.17	26.53	19.17	14.17	16.67	17.84
AGRA SP 07	20.56	13.06	16.81	17.50	17.64	17.57	26.50	20.00	23.25	19.72	44.44	32.08	22.43
AGRA SP 08	14.44	11.90	13.17	17.78	11.11	14.44	25.81	17.22	21.52	15.56	55.56	35.56	21.17
AGRA SP 09	21.67	33.06	27.36	20.56	37.78	29.17	26.11	18.89	22.50	21.11	31.94	26.53	26.39
AGRA SP 11	6.97	19.17	13.06	4.56	6.11	5.34	11.92	6.91	9.42	0.56	20.83	10.69	8.49
AGRA SP 12	13.06	16.94	15.00	28.61	15.28	21.94	14.83	14.72	13.78	3.61	34.17	18.89	17.40
AGRA SP 13	18.89	35.83	27.36	31.67	15.83	23.75	52.78	62.22	57.50	36.94	69.44	53.19	39.20
AGRA SP 14	15.83	17.28	16.55	16.56	2.22	9.39	15.26	16.36	15.81	18.06	7.83	12.94	13.67
AGRA SP 16	3.06	6.11	4.58	10.00	5.71	7.86	5.26	5.56	5.41	0.95	22.50	11.72	7.39
AGRA SP 17	1.94	22.78	12.36	1.94	4.44	3.19	16.94	5.00	10.97	10.00	4.17	7.08	8.40
AGRA SP 19	23.89	13.33	18.61	29.17	17.74	23.46	36.39	23.06	29.72	6.67	57.78	32.22	26.00
AGRA SP 20	10.00	33.89	21.94	15.00	13.33	14.17	20.00	21.39	20.69	4.72	35.00	19.86	19.17
AGRA SP 23	13.89	25.56	19.72	13.61	17.36	15.49	18.61	21.67	20.14	15.83	40.83	28.33	19.67
AGRA SP 24	7.22	16.11	11.67	9.33	16.11	13.14	9.72	7.78	8.75	2.39	18.06	10.22	10.94
AGRA SP 25	8.25	19.72	14.31	16.67	8.33	12.50	16.67	18.33	17.50	0.56	16.67	8.61	12.12
FV	18.95	13.61	16.28	14.56	11.71	13.14	21.26	16.83	19.05	22.62	29.83	26.23	18.67
SED (5%) = 4.41													

FV = Farmers' check/standard; Genotypes highlighted were the proposed varieties for release.

Table 5: Storage root dry matter content (%) of the sweetpotato genotypes across ecozones over two years

Genotype	Ecozone												Grand mean
	Coastal savannah			Forest			Guinea savannah			Transition			
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	
AGRA SP 01	41.46	41.54	43.00	44.10	41.51	42.81	42.12	43.22	42.67	38.13	38.88	44.82	41.75
AGRA SP 04	46.20	46.46	46.33	44.22	43.37	43.79	48.41	41.61	45.01	45.76	42.03	38.49	44.76
AGRA SP 05	47.26	48.29	47.77	44.58	41.07	42.83	46.96	47.67	47.32	44.40	40.54	44.51	45.10
AGRA SP 06	46.67	47.01	46.84	41.64	41.62	41.63	45.70	47.72	46.71	39.44	37.09	47.03	43.36
AGRA SP 07	42.31	45.64	43.97	43.59	42.05	42.82	43.59	44.86	44.23	38.97	37.85	42.46	42.36
AGRA SP 08	42.71	44.92	43.81	40.91	41.98	41.45	44.59	45.06	44.82	39.12	35.78	37.45	41.88
AGRA SP 09	41.38	41.64	41.51	42.09	43.39	42.74	36.67	40.32	38.49	39.50	37.01	38.25	40.25
AGRA SP 11	49.27	46.50	47.88	44.64	44.36	44.50	45.85	43.17	44.51	46.34	41.42	43.88	45.19
AGRA SP 12	49.89	45.88	47.88	41.77	43.71	42.74	47.40	46.66	47.03	47.76	41.17	44.47	45.53
AGRA SP 13	41.45	44.68	43.06	34.95	37.83	36.39	44.95	43.83	44.39	39.95	43.29	41.62	39.71
AGRA SP 14	39.38	38.40	38.89	33.66	34.42	34.04	37.64	37.01	37.33	33.66	27.05	28.80	34.76
AGRA SP 16	32.33	35.59	33.96	30.85	39.12	34.98	38.74	37.98	38.36	30.85	29.80	29.96	34.32
AGRA SP 17	38.27	35.19	36.73	30.01	28.26	29.13	45.98	34.88	40.43	35.97	28.89	32.43	34.68
AGRA SP 19	36.03	36.22	36.12	32.06	36.31	34.19	38.55	40.83	39.69	35.00	29.78	32.39	35.60
AGRA SP 20	38.60	38.69	38.64	33.68	35.20	34.44	31.95	36.33	34.14	36.79	32.78	34.78	35.50
AGRA SP 23	44.12	48.38	46.25	41.31	44.41	42.86	39.93	44.61	42.27	46.28	39.72	43.00	43.59
AGRA SP 24	39.07	43.42	41.24	32.61	41.76	37.19	40.17	41.12	40.65	36.58	33.05	34.81	38.47
AGRA SP 25	40.46	36.78	38.62	33.43	36.88	35.15	34.07	35.70	34.88	37.06	31.63	34.35	35.75
FV	39.22	37.69	38.46	42.26	45.78	44.02	41.40	37.45	39.43	30.87	39.39	35.13	39.26
SED (5%) = 1.18													

SED (5%) = 1.18

FV = farmers' check/standard; genotypes highlighted were the proposed varieties for release.

sweetpotato virus disease, sweetpotato weevil and *Alcidodes*. Cooking quality preference of the genotypes was comparable to the farmers' check (Figure 1). Beta-carotene content of the genotypes across ecozones over two years ranged from 0.73 mg/100 g DW (AGRA SP 11) to 28.46 mg/100 g DW (AGRA SP 20). Their iron and zinc values were 1.36–2.24 mg/100 g DW and 0.67–1.35 mg/100 g DW. These values were given by AGRA SP 24 and AGRA SP 16. The highest (18.12%) and the lowest (10.94%) total sugar content were given by AGRA SP 20 and AGRA SP 06, respectively, while AGRA SP 04 and AGRA SP 16 gave the highest (79.49% DW) and the lowest (67.73% DW) starch content, respectively (Table 6).

4 Discussion

Mother–baby trial approach helped the farmers to gain experience with a few of the sweetpotato genotypes and rigorously assess them. Its use in the evaluation of crop varieties has been reported (Muungani *et al.* 2007; Ndhlela *et al.* 2007). The use of ABS in sweetpotato breeding has also been reported (Andrade *et al.* 2017).

Significant $G \times E$ for storage root dry matter, beta-carotene, iron, and zinc content indicates that the sweetpotato genotypes varied for these traits relative to the different environments. Significant $G \times E$ for storage root dry matter and beta-carotene content has been reported (Chiona 2009; Oduro 2013). $G \times E$ interaction is important in evaluating genotype adaptation, selecting parents and developing genotypes with improved end-product quality (Ames *et al.* 1999), and may complicate selection for such traits (Rosielle and Hamblin 1981; Falconer and Mackay 1996; Martin 2000; Ebdon and Gauch 2002; Gauch 2006). This is because progress from selection is realized only when the genotypic effects can be separated from the environmental effects (Miller *et al.* 1958). However, beta-carotene could be an exemption because of the orange-flesh colour associated with it (Gruneberg *et al.* 2015). The non-existence of $G \times E$ for storage root yield suggests that progress from selection for storage root yield can be realized (Mohammed *et al.* 2012; Nwangburuka and Denton 2012).

Significant differences observed among the sweetpotato genotypes for the traits indicate that superior genotypes can be identified and selected. The storage root yield of 11 of the sweetpotato genotypes tested was either higher or comparable to the farmers' best-bet. This

Figure 1: Cooking quality preferences for the sweetpotato genotypes across ecozones over two years.

indicates that farmers will adopt these genotypes along with their other preferred attributes.

Significant differences have been reported among different sweetpotato genotypes evaluated earlier elsewhere for dry matter, starch and sugar content (McLaurin and Kays 1992; Morrison et al. 1993; Ravindran et al. 1995; Kays et al. 2005; Gasura et al. 2008; Aina et al. 2009; Shumbusha et al. 2014). The high dry matter content of these sweetpotato genotypes is an important attribute for meeting the needs of consumers in Ghana and West Africa.

Suitability of a variety depends on the characteristics a farmer is looking for and includes sensory characteristics (Ndolo et al. 2001), and also diseases and pest tolerance. Of the 18 sweetpotato genotypes presented in the results, 11 were preferred as the farmers' best-bet when cooked. Stakeholders prefer sweetpotatoes with high storage root dry matter because that suits their food preparation preferences. Cooking causes changes in physical, sensory and chemical characteristics of the final product (Vitrac et al. 2000; Fontes et al. 2011). Low dry matter varieties lose mealiness when cooked, affecting textural characteristic preference. They also

absorb more oil when fried, which is not economical to the processors and not healthy to the consumers.

Sugar content of the sweetpotato genotypes was comparable to those reported (Grüneberg et al. 2009b). The 11 non-sweet and less sweet genotypes selected during sensory test make them the staple-type sweetpotatoes preferred by Ghanaians. This is because sweetpotato genotypes that are non-sweet and less sweet allow daily consumption (Lebot 2010).

Sweetpotato has a considerable amount of genetic variation for beta-carotene (Manrique and Hermann 2000). Diversity in sweetpotato flesh colour has been reported (Warammboi et al. 2011). Beta-carotene content increases with increased intensity of the orange-flesh colour of the storage root (Baafi et al. 2016a) and is used in addressing vitamin A deficiency (Low et al. 2007; Low 2013; 2017). The range of values obtained in this study was comparable to those reported by Grüneberg et al. (2009a).

All the genotypes were resistant to sweetpotato virus disease, sweetpotato weevil and *Alcidodes*, which are the major disease and pests attacking sweetpotato. This indicates that the superior genotypes when released as commercial varieties will be preferred by farmers.

Table 6: Quality traits of the sweetpotato genotypes across ecozones over two years

Genotype	Quality traits				
	Beta-carotene (mg/100 g) DW	Total sugars (%) DW	Starch content (%) DW	Iron (mg/100 g) DW	Zinc (mg/100 g) DW
AGRA SP 01	2.06	16.13	75.77	1.49	0.86
AGRA SP 04	2.51	11.10	79.49	1.60	0.76
AGRA SP 05	2.38	10.97	78.26	1.55	0.77
AGRA SP 06	7.25	10.94	76.55	1.65	0.89
AGRA SP 07	7.25	15.29	76.57	1.47	0.73
AGRA SP 08	7.25	14.55	77.45	1.45	0.81
AGRA SP 09	2.85	14.47	77.01	1.40	0.85
AGRA SP 11	0.73	15.06	76.44	1.57	0.78
AGRA SP 12	3.78	11.47	78.65	1.49	0.73
AGRA SP 13	11.38	16.56	74.62	1.39	0.72
AGRA SP 14	6.03	16.57	73.03	1.82	1.06
AGRA SP 16	15.31	17.01	67.73	2.24	1.35
AGRA SP 17	16.14	17.29	68.01	2.03	1.21
AGRA SP 19	21.10	17.08	73.93	1.47	0.86
AGRA SP 20	28.46	18.12	70.41	1.65	0.89
AGRA SP 23	16.30	15.70	76.33	1.54	0.76
AGRA SP 24	6.92	15.15	76.65	1.36	0.67
AGRA SP 25	2.52	16.60	73.58	1.61	0.89
SED (5%)	0.96	0.84	1.85	0.08	0.05

5 Conclusion

Based on the cooking quality preference, storage root yield, dry matter content, taste and resistance to major diseases and pests relative to farmers' best-bet, 10 genotypes AGRA SP 04, AGRA SP 05, AGRA SP 06 and AGRA SP 12 (bland-staple taste); AGRA SP 07, AGRA SP 09 and AGRA SP 13 (less sweet-staple taste); and AGRA SP 23, AGRA SP 19 and AGRA SP 20 (less-sweet orange-flesh) were recommended for release as commercial varieties to farmers. Four of these genotypes, AGRA SP 07, AGRA SP 09, AGRA SP 13 and AGRA SP 20, were officially released by the National Seed Council of Ghana as commercial varieties in June 2019 after recommendation for their release by the National Varietal Release and Registration Committee in 2018. Their respective varietal names are CRI-Vern Gracen, CRI-AGRA SP09, CRI-AGRA SP13 and CRI-Kofi Annan.

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