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Original Article

Fruit and Juice Metric Characteristics of Two Yellow Passion Fruit (*Passiflora edulis* Degener) Genotypes Grown in Southeastern Nigeria

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Abstract

An investigation was undertaken to determine the fruit and juice metric traits of fresh fruits obtained from two yellow passion fruit genotypes grown in south-eastern Nigeria in two seasons. The passion fruit genotypes (Conventional and KPF-4) received 0, 10, 20, 30, 40 t ha^{-1} poultry manure (PM) rates in 2014 and 0, 10, 20 t ha^{-1} PM, 5 t ha^{-1} PM + 200 kg ha^{-1} NPK 15:15:15, 10 t ha^{-1} PM + 200 kg ha^{-1} NPK and 400 kg ha^{-1} NPK in 2016. Ten ripe and freshly dropped fruits in 2015 and 2017 were picked and taken to the laboratory. Fruit and juice metric traits (such as fruit length, circumference, pulp weight, juice volume and weight) were measured. Data collected were subjected to analysis of variance following the procedure for split-plot experiment in completely randomized design. KPF-4 significantly ($p<0.05$) produced longer, wider and heavier fruits than the Conventional in 2015 whereas in 2017 all the fruit metric traits did not significantly ($p>0.05$) differ between the genotypes. Juice volume (682 ml) and pulp fresh weight (942 g) in 2015 were significantly highest in the Conventional when they received 20 or 40 t ha^{-1} PM. Application of 10 t ha^{-1} PM + 200 kg ha^{-1} NPK in 2016 enhanced the production of highest juice volume (723 ml) and pulp fresh weight (770 g) in the Conventional. Juice percentage and fruit metric traits of yellow passion fruit could be enhanced with the application 20 t ha^{-1} PM, considering lesser cost of PM procurement, or combined application of 10 t ha^{-1} PM + 200 kg ha^{-1} NPK.

Keywords: characteristics; fertilizer; fruit juice; genotype; inorganic; organic; yellow passion fruit

Introduction

Passion fruit (*Passiflora edulis* Degener) belongs to the Passifloraceae family. Edible varieties include the yellow and purple passion fruit. The major varieties that are grown worldwide include yellow (*Passiflora edulis* f. *flavicarpa* Degener), purple (*Passiflora edulis* Sims f. *edulis*) and giant variety called giant granadilla (*Passiflora quadrangularis*) (Ferreres *et al*., 2007). The crop, which is a vine, is cultivated majorly because of the edible pulp and juice. The fresh ripe passion fruits can be sold directly but the pulp and juice can also be consumed raw or as frozen pulps, jams, yoghurts (da Silva *et al*., 2015). The juice is also blended with other fruits in wine and juice industries for the production of other unique products. Presently, passion fruit juice is utilized in some fruit markets and smoothie outlets and stores in Nigeria (Field survey, Personal communication). But, the crop is relatively known by few farmers in southeastern Nigeria.

The undiluted juice of passion fruit is highly concentrated and it has rich flavor and strong, but pleasant aroma (Knight and Sauls, 2005). Passion fruit juice is a good source of ascorbic acid (vitamin C) and carotenoids (vitamin A). The passion fruit seed which is advised to be consumed together with the pulp is a rich source of magnesium, an essential mineral that plays a prominent role in carbohydrate metabolism, proper heartbeat and nerve transmission (Sano *et al*., 2011). The seeds also contain piceatanol and scirpusin B, polyphenolic compounds that have strong antioxidant activity. It offers cardiovascular health benefits and exerts vasorelaxant effect (Sano *et al*., 2011). According to Chau and Huang (2004) and Chau *et al*. (2005), the seeds also possess insoluble dietary fiber (64 g/100 g) which offer an effective functional ingredient to promote intestinal function.

Realizing the importance of passion fruit, the Kenya Agricultural Research and Livestock Organization (KARLO) developed KPF-4 among other two (KPF 11 and KPF 12) hybrids (KARLOS, 2014) and were released in 2011. Mwirigi *et al*. (2016) noted that KPF-4 has higher preference than the other two hybrids as it has higher fruit

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yields, juice content and quality. However, the external and internal characteristics of passion fruit have been noted to be influenced by fertilization, among other factors (Pacheco *et al*., 2017). But the characteristics response of passion fruit to fertilization vary according to the species, amount and types of fertilizers utilized (Weston and Barth, 1997; Mattheis and Fellman, 1999; Aular *et al*., 2014). The fruit and juice metric characteristics of KPF-4 have not been elucidated. Hence, the objective of the present study was to evaluate the fruit and metric traits of the yellow passion fruit hybrid (KPF-4) alongside an existing yellow passion fruit genotype in Nigeria as influenced by fertilizer application.

Materials and Methods

Experimental site, laboratory and fruits utilized

Fresh yellow passion fruits were picked from passion fruit vines established in the teaching and research farm of the Department of Crop Science, University of Nigeria, Nsukka (longitude 07° 29' N, latitude 06° 51' E with 400 m above sea level). During the field study, the total annual rainfall was 1410 mm and 1554 mm, respectively in 2015 and 2017. Mean minimum and maximum temperatures were 21 °C and 30 °C, respectively and average relative humidity was 71% and 53% in 2015 and 2017, respectively.

In 2014 (first year of transplanting), two yellow passion fruit genotypes (Conventional and KPF-4) received five poultry manure rates (0, 10, 20, 30, 40 t ha^{-1}). In 2016 (second year of transplanting), the two passion fruit genotypes were treated with six fertilizer treatments namely no fertilizer, 10 t/ha poultry manure (PM), 20 t ha^{-1} PM, 5 t ha^{-1} PM + 200 kg ha^{-1} NPK, 10 t ha^{-1} PM + 200 kg ha^{-1} NPK, 400 kg ha^{-1} NPK. The grade of the inorganic fertilizer was NPK 15:15:15. The physico-chemical properties of the soil and poultry manure used are presented in Table 1.

The choice of combining organic and inorganic fertilizers in the 2016 was because of superior and sustainable performance of passion fruit as regards growth and fruit yield with 20 t ha^{-1} poultry manure application over other PM rates (Ndukwe and Baiyeri, 2018a). In both crop cycles, the experimental layout was split-plot replicated three times. In each cropping season, the main plots were assigned to the genotypes while the sub-plots were allocated to the fertilizer treatments. The soil amendments were applied at one month after transplanting. Other cultural practices were as described by Ndukwe and Baiyeri (2018a).

Naturally, the yellow passion fruit turns from green to yellow on the vines, thereafter the fruit abscise and drop on the ground when matured. Hence, ten ripe and fresh passion fruits per replicate were picked from the ground directly under the vines according to the treatment and treatment combinations. The juice extractions were done in the laboratory of Food Science and Technology, Nnamdi Azikiwe University, Awka. The fresh fruits were washed with sterile water and thereafter cut transversely with the aid of a sharp knife. The pulp, containing the aril and the seeds, were scooped out into a cheese cloth. The cheese cloth containing the fruit pulp was continuously squeezed until all the juice was extracted from the pulp. This was done separately for each treatment combination (genotype x poultry manure rate or fertilizer) for each crop cycle.

Data collection and analysis

Data on fruit and juice metric traits were collected. These were fruit weight, fruit length, fruit circumference, fruit volume, aggregate juice volumes, individual and aggregate juice weights, pulp fresh weight, juice-to-fruit ratio and rind fresh weight. Juice volume was measured with a volumetric cylinder and expressed in millilitre (ml). Juice-to-fruit ratio was determined as the ratio of the aggregate weight of juice and aggregate weight of fresh fruits.

Table 1. Physicochemical characteristics of composite soil sample of the experimental site and poultry manure used in 2014 and 2016

Physical properties	2014		2016	
	Top soil (0-20 cm)	Poultry manure	Top soil (0-20 cm)	Poultry manure
pH (H_2O)	5.00	8.8	5.70	8.1
pH (KCl)	4.50	8.6		
Organic carbon (%)	0.279	12.369	1.392	13.950
Organic matter (%)	0.482	21.324	2.062	24.062
Sand (%)	61	-	85	-
Silt (%)	7	-	9	-
Clay (%)	32	-	6	-
Textural class	Sandy clay loam	-	Sandy loam	-
Chemical properties				
Nitrogen (%)	0.154	2.942	0.126	3.643
Available phosphorus (ppm)	20.00	0.953 (%)	8.390	0.388 (%)
Potassium (meq/100g)	Trace	0.145 (%)	0.108	3.881
Calcium (meq/100g)	2.40	104.00	8.800	28.400
Magnesium(meq/100g)	19.60	384.00	1.200	12.200
Sodium (meq/100g)	1.243	0.0195 (%)	0.072	1.724
Cation exchangeable capacity (meq/100g)	26.00	-	16.00	-
Base saturation (%)	44.49	-	63.63	-
Al^{3+} (meq/100g)	-	-	Trace	-
H^{+} (meq/100g)	29.0	-	1.40	-

Pulp fresh weight was the weight of the fruit juice together with the seeds. The weights of the juice, pulp and rind were measured with digital weighing balance (TH-9801) and the results expressed in grams (g). Juice volume was measured with a measuring cylinder. The whole processes of juicing and measurements were done five times within September and October (peak period of fruit dropping) of each crop cycle.

Analysis of variance was carried out on the data obtained from the juicing processes following the procedure outlined for split-plot experiment using GENSTAT (2007). Mean separation of treatment means were done using Fisher's least significant difference at 5% significance level. Pearson product moment correlation coefficient was employed to determine significant relationship between some fruit and juice metric characteristics with the aid of SPSS 22.0.0 (SPSS, 2013).

Results

Fruit metric traits of yellow passion fruit

The KPF-4 genotype significantly ($p<0.05$) produced longer and wider fruits than the Conventional in 2015 (Table 2). Fruit volume and rind fresh weight were also higher with the KPF-4 fruits than the Conventional fruits. The fruit length, fruit circumference, fruit volume and rind fresh weight of fruits picked in 2017 did not significantly ($p>0.05$) differ between the two genotypes (Table 3).

Poultry manure rates significantly influenced some fruit characteristics in 2015 (Table 2). The fruit circumference (20.09 cm), fruit volume (2163 cm^3) and rind fresh weight (212.9 g) were highest with the application of 40 t ha^{-1} poultry manure although the mean values did not significantly differ with 20 or 30 t ha^{-1} poultry manure application. However, there was 7.7%, 22% and 38% increase in fruit circumference, fruit volume and rind fresh weight of fruits produced with 40 t ha^{-1} poultry manure application compared with the fruits produced without poultry manure. In 2017, all the fruit metric traits did not vary between the genotypes (Table 3).

The interaction of genotype and poultry manure rates in 2015 showed that highest mean values for fruit circumference (21.33 cm) and volume (2595 cm^3) were produced by KPF-4 with 30 t ha^{-1} poultry manure application (Table 4). Rind fresh weight (252 g) was also highest in KPF-4 but with 10 t/ha_{-1} poultry manure application. Nonetheless, these mean values were not significantly ($p>0.05$) different with the values recorded with other poultry manure rates applied to KPF-4. On the other hand, the interaction of genotype and fertilizer in 2017 indicated that fruit length (11.08 cm), fruit circumference (21.29 cm) and fruit volume (2179 cm^3) were highest in the Conventional and KPF-4 (for fruit circumference) with 10 t ha^{-1} PM + 200 kg ha^{-1} NPK fertilizer application. Obviously, these values were significantly higher than the fruits that received no fertilizer (Table 5).

Table 2. Main effects of genotype and poultry manure rates on fruit metric traits of yellow passion fruit grown in the field in 2015

Genotype	Fruit length (cm)	Fruit circumference (cm)	Fruit volume (cm^3)	Rind fresh weight (g)
Conventional	9.02	18.00	1544	145.9
KPF-4	10.67	20.75	2417	224.4
$LSD_{0.05}$	0.65	1.18	362.2	42.61
Poultry manure rate (t/ha)				
0	9.51	18.65	1768	154.1
10	9.79	19.27	1958	203.8
20	9.91	19.49	2007	170.0
30	9.90	19.39	2009	185.0
40	10.13	20.09	2163	212.9
$LSD_{0.05}$	ns	0.68	217.5	41.92

Table 3. Main effects of genotype and fertilizer on fruit metric traits of two yellow passion fruit genotypes grown in the field in 2017

Genotype	Fruit length (cm)	Fruit circumference (cm)	Fruit volume (cm^3)	Rind fresh weight (g)
Conventional	10.42	19.76	1914.0	222.8
KPF-4	10.21	20.22	1928.0	236.3
$LSD_{0.05}$	ns	ns	ns	ns
Fertilizer				
No fertilizer	10.23	18.47	1672.0	168.6
10 t/ha PM	10.41	20.90	2076.0	246.6
20 t/ha PM	10.04	20.28	1921.0	248.2
5 t/ha PM+200 kg/ha NPK	10.29	19.90	1900.0	233.1
10 t/ha PM+200 kg/ha NPK	10.84	20.93	2178.0	249.4
400 kg/ha NPK	10.08	19.46	1779.0	231.3
$LSD_{0.05}$	0.54	0.65	160.4	62.4

Table 4. Main effects of genotype and poultry manure rates on fruit metric traits of yellow passion fruit grown in the field in 2015

Genotype	Poultry manure rate (t/ha)	Fruit length (cm)	Fruit circumference (cm)	Fruit volume (cm^3)	Rind fresh weight (g)
Conventional	0	8.79	17.27	1379	128.2
	10	8.79	17.71	1453	155.7
	20	9.06	18.36	1604	116.3
	30	8.91	17.45	1422	136.0
	40	9.57	19.21	1864	193.5
KPF-4	0	10.22	20.02	2157	180.0
	10	10.79	20.84	2463	252.0
	20	10.77	20.62	2409	223.6
	30	10.89	21.33	2595	234.0
	40	10.70	20.96	2462	232.4
$LSD_{0.05}$		ns	1.20	376.8	59.74

Table 5. Combined effect of genotype and fertilizer on fruit metric traits of two yellow passion fruit genotypes grown in the field in 2017

Genotype	Fertilizer	Fruit length (cm)	Fruit circumference (cm)	Fruit volume (cm^3)	Rind fresh weight (g)
Conventional	No fertilizer	10.81	19.58	1994.0	170.2
	10 t/ha PM	10.45	20.84	2093.0	234.7
	20 t/ha PM	9.61	19.67	1764.0	261.0
	5 t/ha PM+200 kg/ha NPK	10.31	19.18	1797.0	245.5
	10 t/ha PM+200 kg/ha NPK	11.08	20.57	2179.0	208.8
	400 kg/ha NPK	10.24	18.74	1707.0	216.2
KPF-4	No fertilizer	9.65	17.35	1400.0	167.0
	10 t/ha PM	10.37	20.96	2059.0	258.5
	20 t/ha PM	10.47	20.89	2077.0	235.3
	5 t/ha PM+200 kg/ha NPK	10.28	20.61	2002.0	252.9
	10 t/ha PM+200 kg/ha NPK	10.60	21.29	2177.0	257.3
	400 kg/ha NPK	9.92	20.19	1852.0	246.4
$LSD_{0.05}$		0.76	1.31	272.1	ns

Juice metric traits of yellow passion fruit

In 2015, aggregate juice volume, juice weight and pulp fresh weight did not significantly vary between the two passion fruit genotypes (Table 6). But juice-to-fruit ratio (0.369) was higher in the Conventional than in the KPF-4 genotype. In contrast, rind fresh weight (1247 g) was higher in KPF-4 than the Conventional. The poultry manure rates only influenced the juice-to-fruit ratio and rind fresh weight (Table 6). Highest juice-to-fruit ratio and rind fresh weight were produced by the application of 20 and 40 t ha^{-1}, respectively. Fruits with higher juice percentage had lower mean rind fresh weight and vice versa. On the other hand, all the juice metric characteristics in 2017 did not significantly ($p>0.05$) differ between the genotypes (Table 7). Aggregate juice volume, fresh and dry weights of rinds were significantly higher when the vines received 10 t ha^{-1} PM+200 kg ha^{-1} NPK than when the vines received no fertilizer.

The combined effect of genotype and poultry manure rates in 2015 indicated that the aggregate juice volume (682 ml), juice weight (709 g), pulp fresh weight (942 g) and seed-aril fresh weight (175 g) were significantly highest in the Conventional genotype when they received 40 t/ha poultry manure (Table 8). But growing the Conventional genotype with 30 t ha^{-1} poultry manure resulted in lowest juice volume (410 ml) and juice weight (421 g).

The interaction effect of genotype and fertilizer on the fruit and juice metric traits in 2017, showed that highest aggregate juice volume (723 ml), juice weight (706 g) and pulp fresh weight (770 g) were produced by the Conventional genotype with 10 t ha^{-1} PM+200 kg ha^{-1} NPK application (Table 9). The juice-to-fruit ratio (0.537) was highest in KPF-4 when 5 t ha^{-1} PM+200 kg ha^{-1} NPK was applied. The heaviest fresh fruit rind was produced by the Conventional with 20 t/ha poultry manure application.

Table 6. Main effects of genotype and poultry manure rates on juice metric traits of yellow passion fruit grown in the field in 2015

Genotype	Aggregate juice volume (ml)	Aggregate juice weight (g)	Juice-to-fruit ratio	Pulp fresh weight (g)	Rind fresh weight (g)
Conventional	537.0	558.0	0.369	727.0	811.0
KPF-4	533.0	568.0	0.298	726.0	1247.0
$LSD_{0.05}$	ns	ns	0.014	ns	236.8
Poultry manure rate (t/ha)					
0	466.0	486.0	0.362	657.0	856.0
10	562.0	586.0	0.315	780.0	1132.0
20	572.0	627.0	0.364	730.0	944.0
30	497.0	515.0	0.322	709.0	1028.0
40	576.0	600.0	0.306	757.0	1183.0
$LSD_{0.05}$	ns	ns	0.037	ns	232.9

Table 7. Main effects of genotype and fertilizer on some fruit and juice metric traits of yellow passion fruit grown in the field in 2017

	Aggregate juice volume (ml)	Aggregate juice weight (g)	Juice-to-fruit ratio	Pulp fresh weight (g)	Rind fresh weight (g)	Rind dry weight (g)
Genotype						
Conventional	601	593	0.47	661	222.8	23.6
KPF-4	530	567	0.49	589	236.3	27.8
$LSD_{0.05}$	ns	Ns	ns	ns	ns	ns
Fertilizer						
No fertilizer	519	599	0.487	606	168.6	22.7
10 t/ha PM	523	520	0.450	572	246.6	32.4
20 t/ha PM	504	538	0.476	557	248.2	33.2
5 t/ha PM+200 kg/ha NPK	591	585	0.491	658	233.1	31.8
10 t/ha PM+200 kg/ha NPK	668	658	0.501	716	249.4	35.9
400 kg/ha NPK	589	579	0.477	640	231.3	31.2
$LSD_{0.05}$	120.4	ns	ns	ns	62.4	2.5

Table 8. Interaction effect of genotype and poultry manure rates on juice metric traits of yellow passion fruit grown in the field in 2015

Genotype	Poultry manure rate (t/ha)	Aggregate juice volume (ml)	Aggregate juice weight (g)	Juice-to-fruit ratio	Pulp fresh weight (g)	Rind fresh weight (g)
Conventional	0	453.0	471.0	0.403	634.0	712.0
	10	512.0	535.0	0.333	715.0	865.0
	20	625.0	655.0	0.407	726.0	646.0
	30	410.0	421.0	0.342	619.0	755.0
	40	682.0	709.0	0.361	942.0	1075.0
KPF-4	0	480.0	502.0	0.321	681.0	1000.0
	10	612.0	638.0	0.296	844.0	1400.0
	20	520.0	598.0	0.319	735.0	1243.0
	30	584.0	609.0	0.301	799.0	1300.0
	40	471.0	491.0	0.250	572.0	1292.0
$LSD_{0.05}$		183.4	205.0	0.048	ns	ns

Table 9. Combined effect of genotype and fertilizer on some fruit and juice metric traits of yellow passion fruit grown in the field in 2017

Genotype	Fertilizer	Aggregate juice volume (ml)	Aggregate juice weight (g)	Juice-to-fruit ratio	Pulp fresh weight (g)	Rind fresh weight (g)	Rind dry weight (g)
Conventional	No fertilizer	580	588	0.445	670	170.2	21.5
	10 t/ha PM	576	561	0.474	630	234.7	33.4
	20 t/ha PM	568	559	0.445	609	261.0	33.6
	5 t/ha PM+200 kg/ha NPK	521	521	0.446	770	245.8	35.6
	10 t/ha PM+200kg/ha NPK	723	706	0.524	600	208.8	27.4
	400 kg/ha NPK	636	624	0.510	684	216.0	28.4
KPF-4	No fertilizer	457	610	0.528	543	167.0	20.6
	10 t/ha PM	470	480	0.426	515	258.5	37.8
	20 t/ha PM	439	516	0.506	505	235.3	34.2
	5 t/ha PM+200 kg/ha NPK	661	650	0.537	716	252.9	33.4
	10 t/ha PM+200kg/ha NPK	613	611	0.477	662	257.3	33.6
	400 kg/ha NPK	542	535	0.444	596	246.4	36.9
$LSD_{0.05}$		175.2	ns	0.132	172.4	82.29	ns

Correlations between fruit metric traits and juice metric characteristics

Results of the correlation indicated that aggregate fruit weight and rind fresh weight had significant ($p<0.01$) positive and strong association with the juice volume, juice weight and pulp fresh weight in both 2015 and 2017 (Table 10). Stronger relationship existed between the aggregate fruit weight and the juice metric traits than the rind fresh weight. For instance, correlation coefficients between aggregate fruit weight and juice traits in 2015 were r = 0.814**, 0.815** and 0.820** for juice volume, juice weight and pulp fresh weight, respectively. In 2017, the correlation coefficients were r = 0.890**, 0.933** and 0.950**, respectively for juice volume, juice weight and pulp fresh weight. In comparison to aggregate fresh weight, the rind

Table 10. Correlation coefficients of some fruit and juice metric traits in 2015 and 2017

	2015			2017		
	Juice volume (ml)	Juice weight (g)	Pulp fresh weight (g)	Juice volume (ml)	Juice weight (g)	Pulp fresh weight (g)
Aggregate fresh fruit weight (g)	.814**	.815**	.820**	.890**	.933**	.950**
Fruit length (cm)	.243	.296	.219	.188	.128	.067
Fruit circumference (cm)	.303	.345*	.282	.199	.259	.255
Fruit volume (cm^3)	.284	.336*	.267	.235	.240	.211
Rind fresh weight (g)	.535**	.545**	.678**	.796**	.818**	.816**

* and ** = Correlation is significant at the 0.05 and 0.01 level of significance, respectively

fresh weight had weaker and positive correlation with the juice metric traits in both years (r = 0.535**, 0.545** and 0.678** for juice volume, juice weight and pulp fresh weight, respectively in 2015 and r = 0.796**, 0.818** and 0.816** in 2017). On the other hand, juice weight in 2015 had significant positive but weak relationship with the fruit circumference (r = 0.345*) and fruit volume (0.336*).

Discussion

The variations observed in the fruit length, fruit circumference, rind fresh weight and juice-to-fruit ratio between the two yellow passion fruit genotypes confirmed that the hybrid, KPF-4 are bigger in size as reported by KARLOS (2014). The present study is also in agreement with the report of Ndukwe and Baiyeri (2018a). However, the bigger size of the KPF-4 was not translated to higher juice percentage as claimed by KARLOS (2014). This therefore suggested the need to carry out a detailed characterization of the Conventional genotype which will be significant in revealing the genetic make-up for comparisons with the hybrid, KPF-4. The range of juice percentage (30-37% and 47-49% in 2015 and 2017, respectively) were in conformity with the percentages (30-34% for *Passiflora edulis*) reported by Sema and Maiti (2006).

The significant increase of the aggregate juice volume, juice weight, pulp fresh weight with the addition of fertilizers (20 or 40 t/ha PM and 10 t/ha PM+200 kg/ha NPK in the 2014 and 2016 seasons, respectively) indicated the role of fertilization with respect to nutrient supply and corresponding availability to the vines. The poultry manure and NPK utilized in this study were rich in nutrients such as potassium and nitrogen which are important elements in fresh fruit juice production. Potassium not only improves yields but also benefits other aspects of fruit quality; hence, there is higher potassium demand during fruit development (Ramesh *et al*., 2006). Water use efficiency is also dependent on the potassium concentration of the soil. The juice yield of pineapple was reported to be higher when organic fertilizer (Phos-K) was applied (Owureku-Asare, 2015). In addition, nitrogen nutrition in the vine must have been improved since good potassium nutrition favours rapid conversion of inorganic nitrogen (ammonia and nitrate) into to proteins (Ramesh *et al*., 2006). Ndukwe and Baiyeri (2018b) earlier noted that crude protein of passion fruit juice increased with increase in poultry manure rates (40 t/ha).

Increased poultry manure rate in 2014 and the combined application of poultry manure and NPK in 2016 increased passion fruit juice yield implying that more beneficial soil nutrients were supplied and utilized by the vine for the production of more juice. This is in conformity with an earlier study which reported an increase in juice concentration of sweet passion fruit with increase in nitrogen doses especially with addition of cattle manure (Dutra *et al*., 2016). The combination of organic and inorganic fertilizers has positive and complementary effects on the availability of soil plant nutrients and improvement of soil biophysical characteristics. These complementary advantages of combining organic and inorganic fertilizers enhanced better absorption of nutrients and their utilization for higher juice production among other fruit metric traits. The present study corroborates with previous reports indicating that increased fertilizer rate increased juice volume and percentage of passion fruit (Ani and Baiyeri, 2008), kinnow mandarin (Garhwal *et al*., 2014) and sweet sorghum (Kering *et al*., 2017).

The significant, positive and strong relationships that existed between aggregate fruit weight and juice volume, juice weight and pulp fresh weight in 2015 and 2017 is an indication that any agronomic practice that can increase the fruit weight will also increase the juice metric traits. Hence, the juice metric traits can be predicted from the fruit weight.

Conclusions

The KPF-4 genotypes produced longer, wider and heavier fruits than the Conventional in 2015 whereas in 2017 all the fruit and juice metric traits were not significantly (p>0.05) different between the Conventional and KPF-4 genotypes. Higher juice percentage and fruit metric traits of yellow passion fruit can be produced with the addition of 20 t/ha poultry manure, considering lesser cost of poultry manure procurement. The subsequent season of fruit production showed that the combination of either 5 t/ha or 10 t/ha poultry manure and 200 kg/ha NPK enhanced higher quantity of juice production. The aggregate fruit weight and rind fresh weight were strongly correlated to the pulp fresh weight, juice volume and juice weight, implying that industries or individuals can predict the juice volume and pulp fresh weight from the fresh fruit weight.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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