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Economic analysis of yellow passion fruit production in south-eastern Nigeria under different soil fertility management

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Abstract

Three experiments were conducted from 2014 to 2018 to examine the economics of yellow passion fruit production under different soil fertility management. In 2014, two yellow passion fruit genotypes, that is Conventional and KPF 4, were grown in the field and pot simultaneously under varying rates of poultry manure (PM), including 0, 10, 20, 30 and 40 t/ha. In 2016, the response of the two genotypes to a single and combined application of organic and inorganic fertilisers was evaluated under field conditions, namely no fertiliser application, 10, 20 t/ha PM, 400 kg/ha NPK 15:15:15, 5 t/ha PM + 200 kg/ha NPK, and 10 t/ha PM + 200 kg/ha NPK. The profitability indicators were gross revenue, net revenue, returns per naira invested and the profitability index. In 2014, total variable cost increased significantly ($P < 0.05$) with an increase in PM rates in both the field and pot studies. The highest net returns and returns per naira invested were obtained with the application of 20 t/ha PM. The combined application of 10 t/ha PM + 200 kg/ha NPK recorded the highest gross return, net return and return per naira invested in the 2016 production cycle. Growing the vines without fertiliser application gave significantly least net returns without profit in both production cycles and methods. Consequently, applying 20 t/ha PM was adjudged the most profitable for yellow passion fruit production in the study area, and hence is recommended particularly when organic farming is intended. However, if growers must use inorganic fertiliser, a combined application of 10 t/ha PM + 200 kg/ha NPK will be most profitable.

Key words: benefit-cost ratio; fertiliser; fruit yield; net return; passion fruit

1. Introduction

Passion fruit (*Passiflora edulis*), an emerging crop in south-eastern Nigeria, belongs to the Passifloraceae family. The crop is now cultivated in both tropical and sub-tropical regions of the world, although it is native to Brazil and North-eastern Argentina (Pongener & Alila 2015). The fruit of yellow (*Passiflora edulis* f. flavicarpa Degener) and purple (*Passiflora edulis* Sims f. edulis) passion fruit are the most common edible varieties of the genus *Passiflora*, and are grown worldwide (Kishore *et al*. 2006; Ferreres *et al*. 2007). The concentrated edible pulp and juice are the most economically important part of the crop (Ferrari *et al*. 2004). The pulp is consumed fresh in raw form (Da Silva *et al*. 2015), or is blended with other fruit in wine and juice industries for the production of assorted juice drinks. In addition, the distinct aroma and visual characteristics of the juice of passion fruit make it important for the marketing of the fruit (Abreu *et al*. 2009; Da Silva *et al*. 2015).

The juice extracted from the fruits of passion fruit is of high nutritional value and of great importance to human health (Zas & John 2016). Passion fruit is high in carbohydrates and is a good source of pro-vitamin A, niacin, riboflavin and ascorbic acid (Telesphore & He 2009). Free amino acids that have been found in purple passion fruit juice are arginine, aspartic acid, glycine, leucine, lysine, proline, threonine, tyrosine and valine (Morton 1987). The fruit peel is a good silage material for dairy cattle (Sitthiwong *et al*. 2001), and the seeds of passion fruit are rich in dietary fibre, and contain an appreciable amount of protein and edible oil (Oliveira *et al*. 2011; Morais *et al*. 2017). The oil has been reported to possess similar physicochemical properties to some edible oils (Kobori & Jorge 2005).

Passion fruit production in Nigeria is very low, especially in south-eastern Nigeria, a tropical region where the crop can thrive optimally. Hence, there are no passion fruit farmers within the study area. Yet imported fresh fruit and juice are seen on the shelves of Nigerian supermarkets and stores, while juice concentrates are imported for utilisation by the wine and juice industries. Passion fruit production/enterprise in south-eastern Nigeria can increase crop diversity, bring varieties to the food system, promote the nutrition and health of consumers and generate income for farmers, hence ensuring food security. However, one of the determinants of revenue returns from the production of crops is the level of crop yield, which is greatly influenced by the nutrition of such crop, as well as the fertility management of the land resource for production. The cost of fertility management of arable land can contribute greatly to the production cost of crops, especially in a low-fertile soil as that found in south-eastern Nigeria, which is characterised by high leaching occasioned by high rainfall (Oguike & Mbagwu 2009). It is therefore imperative to determine the most cost-effective means to produce passion fruit in this part of the country.

According to Karani-Gichimu *et al*. (2013), manure is one of the production factors that has the highest effect on the productivity of purple passion fruit in the Central-Eastern and North-Rift regions of Kenya. Previous studies on the effect of poultry manure (PM) rates on the growth, fruit and juice yield of yellow passion fruit in Nsukka, south-eastern Nigeria revealed that 15 to 20 t/ha poultry manure application produced optimum growth, fruit and juice yield (Ani & Baiyeri 2008; Ndukwe & Baiyeri 2018a, 2018b). In another study carried out in Nsukka, the nutritional quality of passion fruit juice was best from passion fruit vines that received a combined application of 10 t/ha poultry manure + 200 kg/ha NPK 15:15:15 (Ndukwe & Baiyeri 2018c). Encouraging rural farmers to produce passion fruit using recommended agronomic practices in south-eastern Nigeria will not be fully actualised if the costs and returns of passion fruit production in the area are not determined. Hence, the broad objective of the present study was to analyse the economics of passion fruit production in Nsukka, south-eastern Nigeria under different rates of poultry manure application and a combination of poultry manure and NPK. This will also guide farmers in terms of the inputs to consider most in order to maximise profit in the production of passion fruit in the study area. Specifically, the objectives were to (i) examine the costs and returns of passion fruit production in the study area, and (ii) estimate the future returns on passion fruit production using cost-benefit methods.

2. Materials and methods

2.1 Study area

The experiment was conducted at the teaching and research farm of the Department of Crop Science, University of Nigeria, Nsukka. The study area is located in a derived savannah, at a longitude and latitude of 07°29'N and 06°51'E respectively, and lies at 400 m above sea level. The soil is classified as an ultisol (Asiegbu 1989). The area has a bimodal annual rainfall distribution that ranges from 1 155 mm to 1 955 mm. Annual temperature ranges from 29°C to 31°C, while relative humidity ranges from 69% to 79%.

2.2 Procurement of seeds and raising of seedlings

Extracted seeds of a yellow passion fruit (*Passiflora edulis* var. flavicarpa) hybrid were sourced from the Kenya Agricultural Research and Livestock Organisation (KARLO) in Thika, Kenya. The hybrid, Kenya passion fruit number 4 (KPF 4), along with KPF11 and KPF12 hybrids, were adjudged to be resistant to fusarium wilt, more tolerant to disease and drought tolerant, with fruits that are bigger in size and juicier than the unimproved varieties (HortiNews 2014). KPF 4 is the sweetest of these new varieties. Ripe yellow passion fruits (Conventional) were also obtained from the research field of the University of Agriculture, Abeokuta, Ogun State, Nigeria. The fruits were cut transversely, then de-pulped and the seeds were extracted. The seeds and juice were separated by squeezing the pulp through cheese cloth in order to separate the aril from the seed. Extracted seeds were rinsed with distilled water and air-dried, packaged in an air-tight container and kept at room temperature before planting. The seeds from KPF 4 and the Conventional genotypes were planted in six-week composted media (3:1 v/v, topsoil and rice husk respectively), potted in three litre nursery pots and kept under a nursery shade for the production of seedlings. Seedlings were maintained in the nursery for three months before transplanting.

2.3 Treatments and field layout

In 2014, a field experiment was established to determine the optimum rate of poultry manure addition in the production of two yellow passion fruit genotypes (Conventional and KPF 4). This study was repeated simultaneously in a pot (30 litre) experiment with the aim of simulating the field performance. In addition, another field experiment was conducted in 2016 involving the two yellow passion fruit genotypes (Conventional and KPF 4) and six fertiliser treatments, which included no fertiliser, 10 t/ha poultry manure (PM), 20 t/ha PM, 5 t/ha PM + 200 kg/ha NPK 15:15:15, 10 t/ha PM + 200 kg/ha NPK, and 400 kg/ha NPK.

Field preparations for the field experiment included clearing of vegetation, and then ploughing and harrowing with the aid of a tractor mounted with a disc plough and harrower. Thereafter, planting holes (20 cm x 20 cm x 25 cm) were dug, with a plant spacing of 2 m x 2 m and 3 m x 3 m for the 2014 and 2016 field experiments respectively. Three-month old passion fruit seedlings were transplanted into these holes in a single-row plot of five passion fruit vines according to the treatment combinations. The fertiliser treatments were applied at one month after transplanting. The experimental layout for the field study was a split plot laid out in a randomised complete block design replicated three times. The main plots comprised the two genotypes, while the subplots were the fertiliser treatments.

The medium used in the pot experiment was topsoil + rice-husk (3:1), which weighed 32 kg on average. The composition was allowed to decompose before the seedlings were transplanted. One seedling was transplanted into each pot. The experimental layout was a split plot laid out in a completely randomised design replicated ten times.

Staking of the vines in the field was done using two wooden poles (2 m high) placed at the end of each row, with horizontal rope (8 mm) connecting the wooden poles. Three other bamboo poles were used to support the trellis to avoid sagging of the horizontal rope during heavy canopy formation by the vines. The vines were trained using a rope connecting the base of the vine to the horizontal trellis. In the pot experiment, however, a single cut bamboo pole with branches was used to stake and train each vine. Other cultural practices were as described by Ndukwe and Baiyeri (2018a).

2.4 Data collection

Mature ripe fruits of passion fruit were picked from the ground under the vines according to the treatment combinations. After sorting the fruit, the cumulative fresh weight of the fruit per single row plot were determined using a weighing balance. The fruit picking continued until fruit dropping ceased.

Data on the costs and returns of producing the fresh yellow passion fruit included the production cost (PC), which is the summation of fixed cost and variable cost, and revenue in naira from the sales of fruit. The variable cost was determined by adding the cost of inputs used and those of all farm operations (Ngbede *et al*. 2014). The inputs included raising of seedlings (seed purchasing, procuring nursery pots, labour in raising seedlings), field preparation (labour during ploughing, harrowing, mapping out of cropping area), procurement of poultry manure, transportation and labour during application, procurement of staking material (cost of wooden poles, rope and transportation) and expenditure on installation of staking materials, manual weeding and irrigation. It is worth noting that, at the time of this study, there was no passion fruit farm in Nsukka or in the agroecological zone. However, imported fruits were found on the shelves of some supermarkets and stores in Awka and the Enugu metropolis. In addition, some smoothie outlets within the these cities utilised the juice for various smoothie combinations, since expatriates and indigenes who know the value of the fruit demand either the raw fruit, raw juice or juice in combination with other juices. Hence, the costs of inputs followed the prevailing market prices in Nsukka during the study. Similarly, the price of fresh fruit of passion fruits was determined by the market price of the fresh fruits in supermarkets as well as smoothie outlets situated in Awka metropolis, Anambra State Nigeria.

The gross revenue was calculated as the product of the passion fruit fresh yield and the prevailing market price of fresh passion fruit in supermarkets and smoothie outlets located in Awka metropolis for the period under (that is at ₦500/kg equivalent to USD1.40/kg). The gross margin was obtained from the differences between gross revenue obtained and total production cost (GM = TR-TC), using the enterprise budgeting technique (Olukosi & Erhabor 1988). The enterprise budgeting technique is specified as follows: TC = TVC + TFC; net returns (NR) = TR – (TVC+ TFC), where TC = total cost of production, TVC = total variable cost, TFC = total fixed cost, NR = net return, TR = total revenue and GM = gross margin, all in naira.

The United States exchange rate was obtained from the official foreign exchange price of the Central Bank of Nigeria at the period of fruit sales. Return per naira invested was determined by cost-benefit analysis (CBR), which is the gross cost (GC) divided by gross benefit (GB), i.e. CBR = GC/GB (objective ii). The profitability index (PI) was also calculated by the ratio of the net return to gross revenue, multiplied by 100 (PI = (NR/GR) x 100).

2.5 Statistical analysis

The recorded data was subjected to analysis of variance following the procedure outlined for the split-plot experiment in a randomised complete block design and a completely randomised block design, as appropriate, using Genstat (2007). Separation of the treatment means was done using the least significant difference (LSD) at the 5% level of significance.

3. Results

3.1 Input cost of yellow passion fruit field production as influenced by poultry manure rates in the 2014 to 2016 field production cycle

The economic analysis of passion fruit field production in the period 2014 to 2016 showed that the total production cost (in naira) per hectare increased significantly ($p < 0.05$) with an increase in poultry manure rates (Table 1). The least (₦1 685 000) and highest (₦3 122 500) production costs were obtained with no manure application and 40 t/ha PM application respectively. Staking accounted for the highest percentage of the total production cost compared with other costs (Figure 1). This was followed by the purchasing and application of poultry manure, especially at an application rate of 30 and 40 t/ha PM. However, land preparation and transplanting of seedlings contributed the smallest percentage of the total cost.

Table 1: Variable input costs (₦) per hectare for yellow passion fruit production in the field in 2014 under different poultry manure rates

	Fixed cost (₦)	Variable cost (₦)	Total cost (₦)
Poultry manure rates (t/ha)			
0	1 685 000	0	1 685 000
10	1 685 000	477 500	2 162 500
20	1 685 000	797 500	2 482 500
30	1 685 000	1 117 500	2 802 500
40	1 685 000	1 437 500	3 112 500
Genotype			
KPF 4	1 685 000	766 000	2 451 000
Conventional	1 685 000	766 000	2 451 000

Note: ₦ = Naira

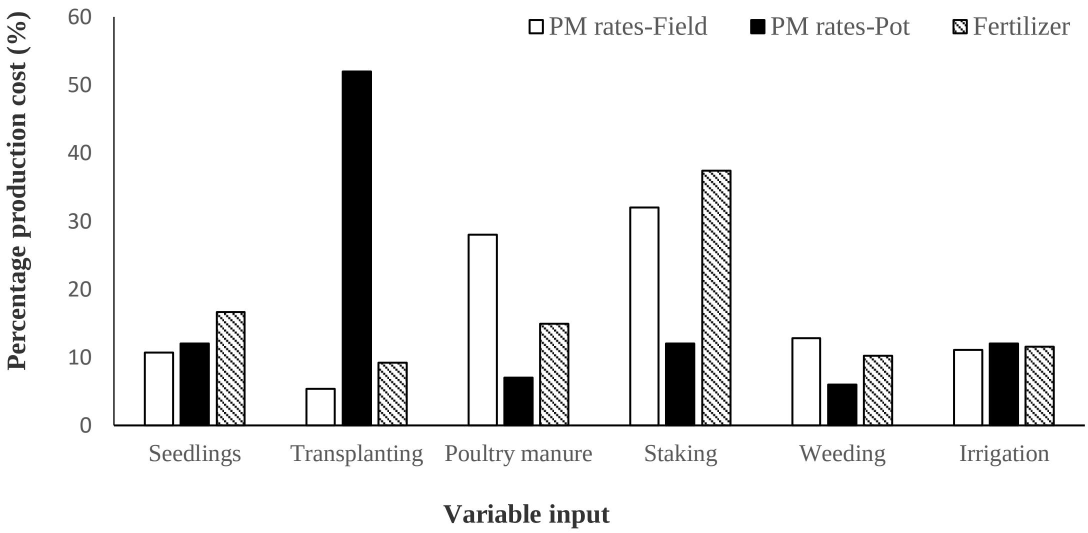

Figure 1: Percentage costs of production variables according to the field and pot experiments
PM rates - Field = Determination of poultry manure rates in the field; PM rates - Pot = Determination of poultry manure rates in the pot; Fertiliser = Single and combined application of organic and inorganic fertilisers

3.2 Input cost of yellow passion fruit production in pots as influenced by poultry manure rates from 2014 to 2016

The production cost of growing the yellow passion fruit in pots progressively increased with the increase in poultry manure rates (Table 2). Similar to field production, the total variable cost of inputs was significantly ($p < 0.05$) lowest and highest with zero and 40 t/ha poultry manure application respectively. In contrast with the field study (2014), transplanting – which involves purchasing of pots, preparation of media and transplanting of seedlings – accounted for the highest percentage of the total variable cost (Figure 1). On the other hand, weeding contributed the smallest percentage of the total production cost.

Table 2: Variable input costs (₦) per hectare for yellow passion fruit production in the pot under varying poultry manure rates in 2014

Poultry manure rates (t/ha)	Fixed cost (₦)	Variable cost (₦)	Total cost (₦)
0	1 950 000	0	1 950 000
10	1 950 000	123 000	2 073 000
20	1 950 000	171 000	2 121 000
30	1 950 000	218 500	2 168 500
40	1 950 000	267 000	2 217 000
Genotype			
KPF 4	1 950 000	155 900	2 105 900
Conventional	1 950 000	155 900	2 105 900

Note: ₦ = Naira

3.3 Input cost of yellow passion fruit field production as influenced by combined organic and inorganic fertiliser application in the period 2016 to 2018

The total production cost was highest (₦1 209 879) with 20 t/ha poultry manure application and lowest (₦851 026) when no fertiliser was applied (Table 3). Total production costs with the combined application of 5 t/ha poultry manure + 200 kg/ha NPK and 10 t/ha poultry manure + 200 kg/ha NPK were ₦983 901.6 and ₦1 063 893 respectively. Similar to the field study in 2014, staking accounted for the highest percentage (37%) of the production cost in the 2016 field study, followed by the procurement of seedlings, and then fertiliser application (Figure 1).

Table 3: Variable input costs (₦) per hectare for yellow passion fruit production in the field in 2016 as influenced by fertiliser

	Fixed cost (₦)	Variable cost (₦)	Total cost (₦)
Fertiliser			
0	857 026	0	857 026
10 t/ha PM	857 026	198 869	1 049 895
20 t/ha PM	857 026	358 853	1 209 879
5 t/ha PM + 200 kg/ha NPK	857 026	132 875	983 901.60
10 t/ha PM + 200 kg/ha NPK	857 026	211 867	1 063 893
400 kg/ha NPK	857 026	66 882	917 908.20
Genotype			
KPF 4	857 026	161 724.33	1 012 750
Conventional	857 026	161 724	1 012 750

Note: ₦ = Naira

3.4 Passion fruit yield, gross monetary return, net revenue, return per naira invested and profitability index from the sale of fresh fruits of passion fruit

In the 2014 field study, the highest gross monetary return (₦6 291 859) was associated with the 40 t/ha poultry manure application (Table 4). However, the net return increased with an increase in poultry manure rate, with the peak net return (₦3 809 359) found to be significant ($p < 0.05$) at 20 t/ha poultry manure application. No application of manure resulted in the least gross monetary return (₦3 240 963) and net return (₦1 555 963).

Table 4: Fruit yield and revenue per hectare from passion fruit production in the field in 2014 to 2016

	No. of fruit per plant	FWT (kg/plant)	FWT (t/ha)	Gross revenue (₦/ha)	Net return (₦/ha)	Return per naira invested	Profitability index
PM rate (t/ha)							
0	35.3	2.59	6.48	3 240 963	1 555 963	0.92	48.01
10	60.3	4.34	10.85	5 425 297	3 262 797	1.51	60.14
20	67.1	5.03	12.58	6 291 859	3 809 359	1.53	60.54
30	64.9	4.72	11.80	5 900 466	3 097 966	1.11	52.50
40	70.4	5.27	13.18	6 587 530	3 465 030	1.11	52.60
$LSD_{0.05}$	15.3	2.10	2.81	1 408 869	1 402 869	0.66	ns
Genotype							
KPF 4	64.1	4.77	11.93	5 964 783	3 513 783	1.46	58.91
Conventional	55.1	4.01	10.03	5 013 663	2 562 663	1.01	51.11
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns

Notes: ₦ = Naira; 1₦ = 0.0028USD; 1 kg of fresh fruit = ₦500 (USD 1.40); FWT = Fresh fruit weight; PM = Poultry manure; $LSD_{0.05}$ = least significant difference at the 5% level of significance; ns = not significant

Similarly, the gross monetary return, net return and return per naira invested increased significantly ($p < 0.05$) with increases in poultry manure rates in the 2014 pot experiment (Table 5). These revenue variables were at their peak at 20 t/ha poultry manure application. The 20 t/ha poultry manure application produced the highest gross return (₦5 195 404), net return (₦3 074 413) and return per naira invested (1.45). Utilising 30 t/ha poultry manure during production gave a return of 1.12 per naira invested. However, there was a 99%, 47% and 63% reduction in the return per naira invested with the application of 0, 10 and 40 t/ha poultry manure respectively compared to the application of 20 t/ha poultry manure.

Table 5: Fruit yield and revenue per hectare from passion fruit production in the pot in 2014 to 2016

	No. of fruits per plant	FWT (kg/plant)	FWT (t/ha)	Gross revenue (₦/ha)	Net return (₦/ha)	Return per naira invested	Profitability index
PM rate (t/ha)							
0	5.50	0.10	0.06	249 084	126 534	0.01	43.1
10	37.40	1.63	0.72	4 079 942	2 006 894	0.98	42.0
20	40.20	2.08	0.69	5 195 404	3 074 413	1.45	52.6
30	40.20	1.85	0.89	4 613 255	2 444 739	1.12	43.5
40	23.80	1.65	0.55	4 115 164	1 898 108	0.82	56.8
$LSD_{0.05}$	10.26	0.57	0.22	1 433 939	1 433 938	0.69	ns
Genotype							
KPF 4	25.9	1.93	0.51	4 829 644	2 723 719	1.28	55.1
Conventional	32.9	0.91	0.65	2 272 228	166 171	0.07	40.2
$LSD_{0.05}$	ns	0.5	ns	1 261 927	1 261896	0.59	9.41

Notes: ₦ = Naira; 1₦ = 0.0028USD; 1 kg of fresh fruit = ₦500 (USD 1.40); FWT = Fresh fruit weight; PM = Poultry manure; $LSD_{0.05}$ = least significant difference at the 5% level of significance; ns = not significant

Combined organic and inorganic fertiliser application significantly ($p < 0.05$) influenced the gross monetary return, net return and return per naira invested in the 2016 field study (Table 6). The lowest cost of production obtained with no fertiliser application could not translate into higher gross or net return than the highest gross return (₦6 505 479), net return (₦5 441 585), return per naira invested (5.11) and profitability index (83.65%) that were obtained with the combined application of 10 t/ha poultry manure + 200 kg/ha NPK. The application of no fertiliser produced the least gross return (₦2 464 411), net return (₦1 613 385) and return per naira invested (1.90).

Table 6: Fruit yield and revenue per hectare from passion fruit production in the field in 2016 to 2018

	Number of fruits per plant	**Fresh fruit weight (kg/plant)**	**Fresh fruit weight (t/ha)**	**Gross revenue (₦/ha)**	**Net return (₦/ha)**	**Return per naira invested**	**Profitability index**
Fertiliser							
0	44.3	4.44	4.93	2 464 411	1 613 385	1.90	65.47
10 t/ha PM	74.0	7.29	8.10	4 049 002	2 999 107	2.86	74.07
20 t/ha PM	64.0	5.71	6.34	3 171 753	1 961 874	1.62	61.85
5 t/ha PM + 200 kg/ha NPK	83.9	7.86	8.73	4 366 132	3 382 230	3.44	77.47
10 t/ha PM + 200 kg/ha NPK	124.0	11.71	13.01	6 505 479	5 441 585	5.11	83.65
400 kg/ha NPK	49.1	5.23	5.82	2 907 593	1 989 684	2.17	68.41
$LSD_{0.05}$	35.13	3.07	3.42	1 707 305	1 707 305	1.68	ns
Genotype							
KPF 4	68.7	6.86	7.63	3 813 152	2 800 401	2.79	73.44
Conventional	77.8	7.22	8.02	4 008 304	2 995 554	2.90	74.73
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns

Notes: ₦ = Naira; 1₦ = 0.0028 USD; 1 kg of fresh fruit = ₦500 (USD 1.40); $LSD_{0.05}$ = least significant difference at the 5% level of significance; ns = not significant

3.5 Net returns and profitability index as influenced by genotype

In the field studies there was no significant difference ($p > 0.05$) in the revenue indices between the two genotypes of passion fruit (Tables 4 and 6). However, both genotypes recorded high revenue returns. Generally, the profitability index obtained from cultivation of the passion fruit in the field ranged between 51.1% and 58.9% and 73.4% and 74.7% in the 2014 to 2016 and 2016 to 2018 production cycles.

On the other hand, growing the vines in pots indicated that KPF 4 significantly ($p < 0.05$) accrued higher net returns (₦2 723 719) and returns per naira invested (1.28), with a profitability index of 55.1%, than the Conventional genotype (Table 5). The Conventional genotype had lower returns per naira invested (0.07), as well as a low profitability index (40.2%) compared to the hybrid.

4. Discussion

The economic analysis revealed varying production costs, which can be attributed to the different poultry manure rates (field and pot studies in 2014) and fertiliser combinations (field study in 2016). The higher production cost with 30 and 40 t/ha poultry manure application in the 2014 field study could not be compensated for with a higher net return compared to other poultry manure rates. On the other hand, the values for yield, net return (₦3 809 359) and return per naira invested (1.53), which were obtained with 20 t/ha poultry manure application in the field, were enough to compensate for the production cost (₦2 482 500) attributed to this rate of poultry manure. A similar result was obtained from the pot study conducted simultaneously with the field experiment in 2014. This result is in agreement with the report of Ngbede *et al*. (2014). It therefore shows that it was most profitable to apply 20 t/ha poultry manure in both the field and pot studies, since the return per naira invested (1.53 and 1.45 for the field and pot respectively) was highest with this treatment. It further shows that there was a 66.3% increase in profit with 20 t/ha poultry manure application in the field compared to no manure application, since the return per naira invested with no poultry manure application in the field and pot studies of 2014 was 0.92 and 0.01 respectively. Similarly, the utilisation of 20 t/ha poultry manure during passion fruit production in the pot was 144% more profitable than applying no manure. It has been noted that, for a business to break even, the value of the benefit/cost ratio (return per naira invested) must be one. When the value is greater than one, then the business is making a profit and, if less than one, the business is running at a loss (Olukosi & Erhabor 1988). The return per naira invested with no poultry manure application in the field and pot studies of 2014, namely 0.92 and 0.01 respectively, reveals that it is not profitable to venture into yellow passion fruit production without fertility amendment, especially in an impoverished soil. The range of profitability indices (46.5% to 59.0% and 66.8% to 86.4% in 2014 to 2016 and 2016 to 2019 respectively) obtained from this study is higher than the values (49.70% to 58.03%) reported by Miyake *et al*. (2016).

Although the production cost (₦1 063 893.6) with the combined application of 10 t/ha PM and 200 kg/ha NPK was high in 2016, the highest fruit yield balanced the production cost, as the gross monetary return (₦6 505 479), net return (₦5 441 585) and return per naira invested (5.11) were the highest compared to the other treatments.

The percentage variable cost in the field studies revealed that staking accounted for the highest percentage (32% to 37%) of the production cost, followed by fertiliser application. The implication is that farmers should consider staking methods and staking materials that could reduce the production cost of passion fruit, bearing in mind the existing materials in the environment. At present, there is a lack of information on the growth, yield and economic responses of passion fruit to different staking methods and staking materials in the study area. On the other hand, fertiliser application accounted for the second highest total variable input, which suggests the importance of considering the quantity of fertiliser to apply for the optimum growth and development of the vines. This was the major objective of the present study, which was to determine the optimum poultry manure rate and fertiliser application that would produce the highest fruit yield and net economic return.

Revenue accrued from the cultivation of both passion fruit genotypes in the field revealed that the hybrid, KPF 4, could be utilised as an alternative to the Conventional genotype, which must have adapted to the environment of the study area. This is in agreement with the report of Ndukwe and Baiyeri (2018a), who note that the fruit yield indices of the Conventional and KPF 4 passion fruit were statistically similar. Higher revenue and profit recorded by KPF 4 in the pot experiment was possible because of higher fruit yield (1.93 kg/plant) produced by the hybrid than that produced by the Conventional genotype (0.91 kg/plant). The passion fruit hybrid was adjudged to have larger fruit (HortiNews 2014) than the existing genotypes.

5. Conclusion

The field studies indicate that the total production cost for the sustainable production of yellow passion fruit in the study area ranged from ₦1 063 893 to ₦2 482 500 (USD 2 980.09 to USD 6 953.78), while the net monetary return ranged from ₦3 809 359 to ₦5 441 585 (USD 10 670.47 to USD 15 242.54). This is an indication that passion fruit production is a profitable enterprise. Farmers in the study area therefore are encouraged to venture into passion fruit production. This can be achieved through community outreach programmes.

However, the staking of passion fruit vines accounted for the highest percentage (32% to 37%) of production costs, followed by fertiliser application. Further studies on different methods of staking are recommended in order to reduce the high cost of production arising from the staking. Similarly, prospective passion fruit farmers in the study area should pay attention to fertility management in passion fruit field. The farmers should endeavour to apply 20 t/ha poultry manure during production for more revenue and, if inorganic fertiliser must be utilised, the combined application of 10 t/ha poultry manure + 200 kg/ha NPK will be more profitable.

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