RESPONSE OF YELLOW PASSION FRUIT (*Passiflora edulis* var. *flavicarpa* DEGENER) TO ORGANIC FERTILISER APPLICATION IN ABEOKUTA, NIGERIA

BY

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ABSTRACT

Yellow Passion Fruit (YPF) is a perennial crop with great importance as flavouring component in fruit juice production due to its distinct aroma, but its growth and yield are limited by nutrient supply. Perennial crops require slow releasing nutrient sources like Organic Fertiliser (OF) for their optimal performance. There is dearth of information on effects of OF on growth and yield of YPF. Therefore, this study was conducted to examine the effects of OF on growth and yield of YPF.

Pot and field experiments were conducted in Abeokuta to assess the effectiveness of Organic Fertiliser (N-0.78g/kg, P-12mg/kg, K-0.07cmol/kg) on growth and yield of YPF. In pot experiment, OF at 0 (control), 0.5 (T1), 1.0 (T2), 1.5 (T3), 2.0 (T4) and 2.5 t/ha (T5) were each mixed with 20 kg top soil in pots arranged in completely randomised design replicated thrice. Four-month old seedlings of YPF at the rate of one seedling per pot were transplanted and monitored for 16 weeks. Data were collected on Vine Length-VL (cm), Vine Diameter-VD (mm), Number of Leaves (NL), Number of Branches (NB) and Leaf Area-LA (cm^2). Nitrogen and potassium uptakes (g/plant) were determined using standard procedures. On the field, T1, T3 and T5 were applied to transplanted seedlings spaced at 3m x 3m. Untreated plots served as control. The experiment was in a randomised complete block design with three replicates and monitored for 24 months. Data were collected on NB, Vine Trusses (VT), Number of Flower Buds (NFB), Number of Flowers (NF) and Fruit Yield (FY) and analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.

In the pot experiment, the OF rates significantly influenced VL, VD, NL, NB, LA, nitrogen and potassium uptakes of YPF. The VL ranged from 83.0±4.2 (T3) and 83.0±1.5 (T4) to 194.3±5.5 (control). The VD ranged from 14.0±1.10 (T4) to 19.7±1.13 (T1), while NL and NB ranged from 10.0±7.5 (T2) to 23.0±9.3 (control) and 1.0±0.23 (T4) to 3.0±0.53 (control), respectively. The LA of YPF under T1 (497.0±4.5), T2 (497.0±4.0), T3 (440.0±10.3) and control (522.1±2.0) were comparable and significantly lower than T4 (531.0±1.2) and T5 (543.0±10.4). Uptakes of nitrogen and potassium were in the order 0.024±0.004 (T1) > 0.016±0.004 (control) > 0.013±0.004 (T5) > 0.012±0.004 (T4) > 0.011±0.004 (T3) > 0.011±0.00 (T2) and 0.062±0.014 (T5) > 0.060±0.010 (T1) > 0.031±0.014 (control), 0.031±0.013 (T2) > 0.023±0.014 (T3), respectively. On the field, SOF rates significantly affected NB, VT, NFB and FY of YPF. Significantly higher NB (15.0±1.7) was obtained under T5, while T1 (7.0±1.5), T3 (7.0±1.4) and control (3.0±0.12) had lower but similar values. Application of T1 resulted in significantly higher VT (4.0±1.1) followed by T3 (3.0±1.1), T5 (3.0±1.0), while control (2.0±1.0) had the lowest. The NFB ranged from 3.0±0.3 (control) to 9.0±0.9 (T5). The FY under T1 (1.21±0.06 t/ha) was significantly higher than T3 (0.66±0.02 t/ha), T5 (0.66±0.03 t/ha), while the control had no yield.

Organic Fertiliser (N-0.78g/kg, P-12mg/kg, K-0.07cmol/kg) at the rate of 0.5 t/ha improved growth and yield of Yellow Passion Fruit in Abeokuta, Nigeria and is therefore recommended.

Keywords: Yellow Passion Fruit, Organic Fertiliser, Seedlings, Nutrient uptake, Nutrient sources

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CERTIFICATION

I certify that this work was carried out by Mrs. Tunrayo Tinuoye JOSEPH-ADEKUNLE in the Department of Agronomy, Faculty of Agriculture, University of Ibadan.

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DEDICATION

This Thesis is dedicated to GOD ALMIGHTY, the Creator, Sustainer and the Pillar that holds all things in place.

LIST OF ABBREVATIONS AND ACRONYMNS

Abbreviation/Acronym	Word
AOAC	Association of Official Analytical Chemists
CB	Cost-Benefit
CBA	Cost Benefit Analysis
CENRAD	Centre for Environmental Renewable Resource management, Research and Development
FAO	Food and Agriculture Organisation
FC	Fixed Cost
ha	Hectare
IFA	International Fertilizer Association
IITA	International Institute of Tropical Agriculture
kg	Kilogramme
LA	Leaf area
LDW	Leaf Dry Weight
masl	Metre above sea level
NOSB	National Organic Standards Board
t/ha	Tonne per hectare
TDW	Total Dry Weight
PF	Passion Fruit
RDW	Root Dry Weight
TC	Total Cost
TFC	Total Fixed Cost
TR	Total Revenue
TSBF	Tropical Soil Biology and Fertility
TVC	Total Variable Cost
UNESCO	United Nations Educational Scientific and Cultural Organisation
USDA	United States Department of Agriculture
VDW	Vine Dry Weight
WAT	Weeks after transplanting
YPF	Yellow Passion Fruit
vs	Visible sphere or visible region

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CHAPTER 1

INTRODUCTION

Passion Fruit (PF) (*Passiflora edulis* Sims) is a juice-producing semi-woody perennial vine, in the family *Passifloraceae*. The genus *Passiflora* comprises of about 450-500 species which occur mainly in tropical and subtropical America. They grow in natural habitats that ranged from desert to rainforest. These habitats cover a wide range of altitudes, from sea level to between 3,000 and 4,500 metres in the Andes. There are three varieties of Passion Fruit that are cultivated, they are the Yellow Passion Fruit (YPF) (*Passiflora edulis* var. *flavicarpa*) which is suited to tropical conditions, the Purple Passion Fruit (*Passiflora edulis* var. *edulis*) which grows best under sub-tropical conditions or high altitudes and the giant granadilla (*Passiflora quadrangularis*) (Van de Plank, 2000; Pradeepkumar, 2007).

The Yellow variety is more prolific, bears large and heavy fruits and has more juice than the Purple one. The yellow form is tolerant to most of the pests and diseases found in the soil which affect the Purple variety. Passion Fruit is highly cherished for its diverse uses; it is eaten fresh, it is used in flavouring of juices, wines, as raw materials in the manufacture of pharmaceuticals and the rind is used as filler for livestock feeds (Britto *et al.,* 2005; Santos and Gilreath, 2006). The fresh fruits find ready market both locally and internationally and offer revenue earning opportunities for developing countries (Thorp *et al*., 2006).

The climate in southwest Nigeria and the existence of many fruit juice industries make the area conducive for its cultivation, yet there is hardly any cultivation (Alegbejo, 2004; Aiyelaagbe *et al.,* 2005). Few indigenous juice industries are currently involved in using the Passion juice concentrate in combination with other fruit juices to produce novel products. For example, the FUMAN's "*Patti blend*" brand is a blend of orange, grapefruit and Passion Fruit juice concentrate. Internationally, attempts have been made to concentrate and clarify the Passion Fruit juice and extract essences from the Passion flowers (Adeyemi, 2010; Alabi, 2010; Hafner *et al*., 2013).

In northern Nigeria, small YPF cultivation by small scale farmers exists but yields are poor. The Brazilian average fruit yield of YPF was 13.42 t/ha/yr but under fertigated condition the average fruit yield was 16.5-17.5 t /ha/yr (Agrianual, 2014). These yield values were however, lower than those earlier recorded (18.5t /ha/yr) under Nitrogen fertilization (Venancio *et al*., 2013). Several works on YPF and other fruits under the Brazilian semi-arid condition have been documented using Humic substances and varying N doses with observed significant increases on growth and development (Baldotto *et al*., 2009; Rebequi *et al*., 2011; Nunes *et al*., 2014; Silva *et al*., 2016).

Passion Fruit can tolerate various soil types but it is best suited to heavy and fast draining sandy loam soils. The best soils are those with pH between 6.5 and 7.5; medium textured rich in organic matter and with less salt content. The soils of southwestern Nigeria are fragile and infertile because they are poorly buffered, low in organic matter content and cation exchange capacity. Attempts to augment the soils' fertility by application of mineral fertilizers are limited by the high costs; scarcity and supply of only one to few nutrients by these fertilizers. The inabilities of these mineral fertilizers to fully furnish essential nutrients when used for horticultural crops production have limited the suitability of these fragile soils for perennial use (Mba, 1996). Full understanding of the ecological and agronomic requirements for cultivation of PF is required to fully exploit its potentials. Some possible constraints to the full exploitation of its great potential in southwest Nigeria are lack of awareness, low yield and lack of information on the nutrient requirements.

Preliminary studies on its nutrient requirements at juvenile stage by Aiyelaagbe *et al.* (1998) suggested that 90 kg/ha N is sufficient for the vegetative phase on impoverished soils of southwestern Nigeria. However Slack and Dirou (2004) in Australia recommended 97 kg N, 17 kg P and 117 kg K/ha applied in four split doses throughout the growth period of PF. Several agricultural practices particularly fertilizer application and watering coupled with other factors such as climate and soil have been identified as essential for fruit production and high crop yield of this crop (Silva *et al.,* 2016).

Ability of growers to supply the nutrients at compatible levels according to the crop's nutrients requirements is important. The developmental and budding phases of YPF require substantial quantities of nutrient particularly Nitrogen which is the most absorbed nutrient. Extracted N is put at 205.5 kg/ha/yr and N exportation through fruit harvest at 44.55 kg/ha for a fruit yield of 16.3 t/ha (Haag *et al.,* 1973). Beneficial effects of organic fertilisers and related substances to soils and plants have been documented. Studies on use of organic fertilisers on commercial fruit crops such as grape (Ferrara and Brunetti, 2008), pineapple (Baldotto *et al*., 2009), custard apple (Cavalcante *et al*., 2012; 2014) and guava (Nunes *et al*., 2014) have focused on increasing the efficiency of nutrients absorption, particularly N. Organic fertilisers exert positive effects on soils due to the slow release of their nutrients and their supply of a host of macronutrients, micronutrients and organic matter that have synergetic effects on the microbial life and soil.

Passion Fruit is a new crop with great potentials that can diversify the crop production system in southwest Nigeria. There is paucity of information on its response to Organic Fertiliser. According to Clements *et al.* (2011) the introduction of new crop species to diversify the crop production systems in an area requires understanding of the inter-relationship of growth resources that will enhance their establishment. They opined that important considerations must be given to availability and quality of resources such as irrigation, rainfall and soil fertility for successful establishment. Studies on Passion Fruit using Humic substances enhanced root growth, higher nutrient availability and chlorophyll biosynthesis. All these are as a result of the influence of Humic substances on chemical, physical and biological soil properties (Ferrara and Brunetti, 2008).

Olubode *et al*. (2018) opined that there is growing research focus into perennial or tree crop production but this requires deeper understanding of their nutrients needs. It suffices that tree crop research is faced with long gestation period and so require that other means of improving yield and productivity through cultural practices be investigated. There is certainly a need to search for fertiliser that not only meets this need but lead to improvement of the knowledge of the conditions necessary for optimal crop growth and establishment.

This hope arises from the fact that fertiliser application has been reported to improve crop growth and development

Presently in Ogun state in the rainforest-savannah transition zone of southwest Nigeria, there is limited documented information on the response of YPF to Organic

Fertiliser application. Varied vegetative growth responses were reported from the few earlier studies (Fagbayide and Joseph-Adekunle, 2002; Aiyelaagbe *et al.,* 2005a; 2005b). It is important to find out whether application of Organic fertiliser can offer such positive responses during introduction and establishment of YPF under the rain forest savannah transition ecology of Abeokuta. This investigation was therefore undertaken on YPF with broad objective to investigate the effects of Organic Fertiliser application on the growth and yield of YPF.

The specific objectives of the study were to:

i. determine the effects of Organic Fertiliser rates on the growth and yield of YPF

ii. assess the effects of Organic Fertiliser rates on the yield of YPF

iii. assess effects of Organic Fertiliser application on the nutrient dynamics of the soil and

iv. examine the cash benefits accruable from YPF cultivation using Organic Fertiliser.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Origin and Distribution of Passion Fruit

Passion Fruit (*Passiflora edulis* Sims) is a semi-woody perennial vine that is native to the Brazilian Amazonia and is grown throughout South, North and Central America; the Caribbean, tropical and subtropical regions of Africa, Asia, Australia and New Zealand. It is most endemic in the forest zone of the southern Brazil from where cultivation had spread to many parts of the sub-tropics and tropics. The PF has three major varieties which are widely cultivated: the Purple variety, which is native to southern Brazil; the Yellow variety and the giant Granadilla which are native to Amazon region of Brazil (Van der Plank, 2000; Copens d'Eckenbrugge, 2001; Falconi-Borja, 2001). Although PF was introduced and grown in most subtropical and tropical regions, it has attained important commercial status in Australia, Hawaii, Brazil, South Africa and Kenya. These areas are reputable for production, processing and utilisation of the crop for its juice (Hafner *et al.*, 2013). In Nigeria, the introduction and cultivation of PF was in the north central, precisely Funtua in Kaduna State but was later introduced to southwest through CENRAD at Ibadan, Oyo State (CENRAD, 1999). Passion Fruit has been classified by botanists as 'new world' specie with about 22 to 24 identified genera (Linnaeus, 1745; 1753; Van der Plank, 2000). Presently, out of over 600 species in more than 20 genera, only about 10 to 12 species are being exploited for their fruits. *Passiflora edulis* has the exclusive designation of Passion Fruit and grows between altitudes of 800 m and 1500 m above sea level (masl) but can survive at higher altitudes. The lowland tropical conditions are found to be the best for the growth of Yellow Passion Fruit while the subtropical areas or at higher altitudes in the tropics for the Purple Passion Fruit. The standard yellow (*Passiflora edulis* f. *flavicarpa* Degener.) and the purple (*Passiflora edulis f. edulis*), differ in pH and starch content with between (pH 2.8 and 0.06% starch) for the yellow and the purple (pH 4.2 and 0.74% starch), with comparatively higher amylose content in former (8.7%) than latter type (5.8%).

Flower initiation and fruit set are favoured by cool temperatures (18°C-23°C) while relatively high temperatures (23°C- 33°C) improve the fruit quality (Van de Plank, 2000; Sema and Maiti, 2006).

2.2 Taxonomy and Botany of Passion Fruit

Passion Fruit belongs to the family *Passifloraceae;* genus *Passiflora* and species *edulis*. The two main varieties commercially cultivated are Yellow (*Passiflora edulis* var. *flavicarpa)* and Purple (*Passiflora edulis* var. *edulis).* Adaptable to the tropics are the Yellow variety and its hybrids. Other varieties that have commercial possibilities are *P. mollissima, P. exonensis, P. quadragularis, P. ligularis, P. cumbalensis, P. manicata, P. mixta and P. trifoliate* but require further breeding efforts. Hybrids developed for commercial cultivation include the Common Purple, Australian Purple, Nelly-Kelly, Kapoho, Sevcik, University round and Yee selections (Jackson, 1986; Morton, 1987; Knight and Sauls, 1994). Passion Fruit common names are granadilla, parcha, parchita, parchita maracuya (Spain); ceibey (Cuba); maracuja peroba (Portugal); grenadille (France), lilikoi (Hawaii) and mountain sweet cup (Jamaica) (Morton, 1987).

The diverse *Passiflora* genus consists of shallow rooted vigorous perennial vines that can reach up to 15 m in length. The vines are herbaceous when young and become woody at maturity (Arena *et al.,* 1994). The vines of YPF when young have ting of red colour but turns green when matured. The tendrils are located at the leaf axils and tinged with red or purple colour and are mainly for climbing and support. The leaves are alternately arranged, deep green, glossy above but pale and dull beneath. They are ovate at juvenile stage and tri-lobed at maturity. The evergreen leaves are approximately 18 cm long, with finely serrated margin and tinged with red or Purple colour (Combees, 1990). The 5 to 7.5 cm wide fragrant regular and showy flower is borne singly at each node on the new growth. The flower of YPF is larger than that of Purple Passion Fruit in diameter. The style and stigma are green and tri-partite with five filaments (Jackson, 1986; Morton, 1987; Combees, 1990; Joy, 2011). The mature fruit of YPF turns from green to deep Yellow or canary yellow when ripe compared to Purple which is dark purple or nearly black in colour. The fruit is round or egg shaped berry with many seeds and the cavity filled with gelatinous aromatic pulp. The fruit contains about 250 black wedge-shaped small and hard seeds (Plates 2.1 and 2.2) (Morton, 1987; Knight and Saul, 1994; FAO, 1998; Joseph-Adekunle, 2006).

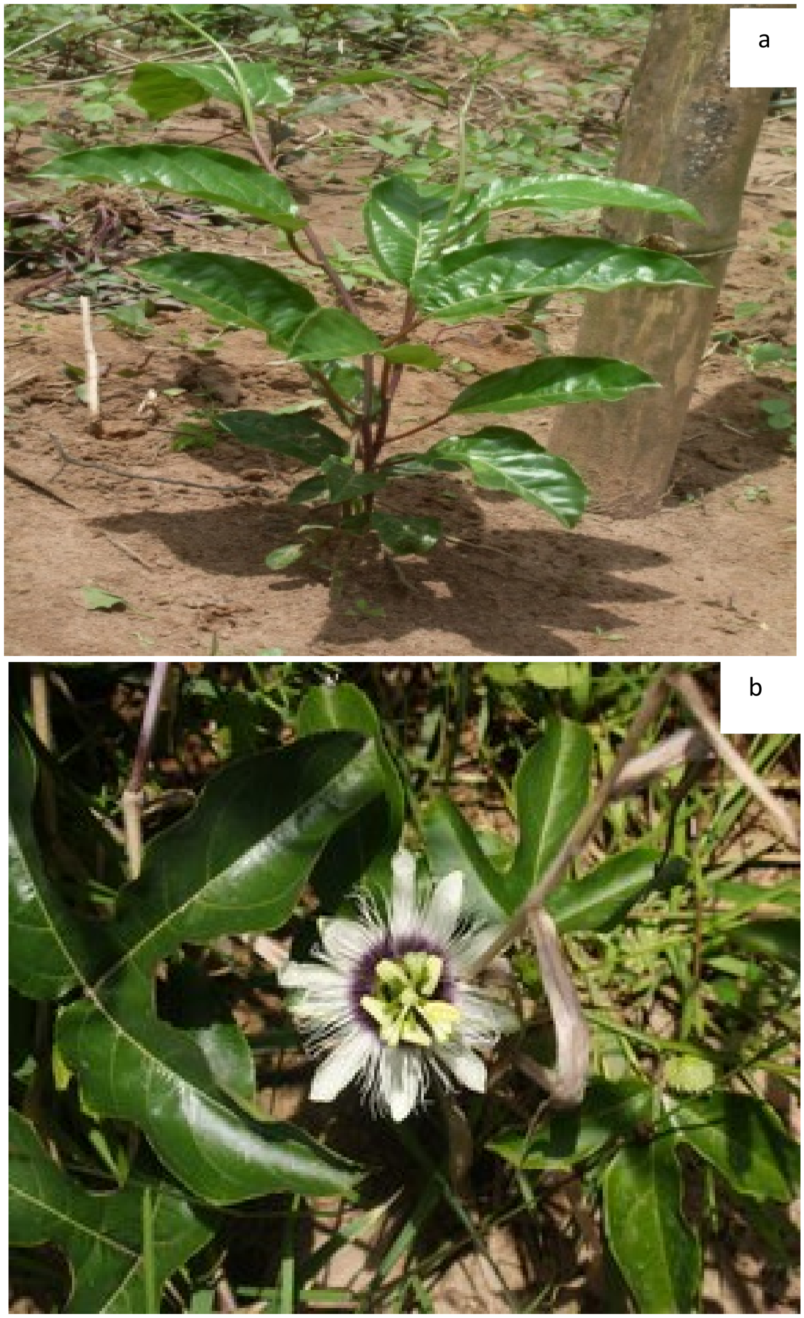

Plate 2.1: *Passiflora edulis* var. flavicarpa (a) Seedling (b) Flower
Magnification × 0.5

Plate 2.2: *Passiflora edulis* var. *flavicarpa* (Mature green fruit)
Magnification × 1

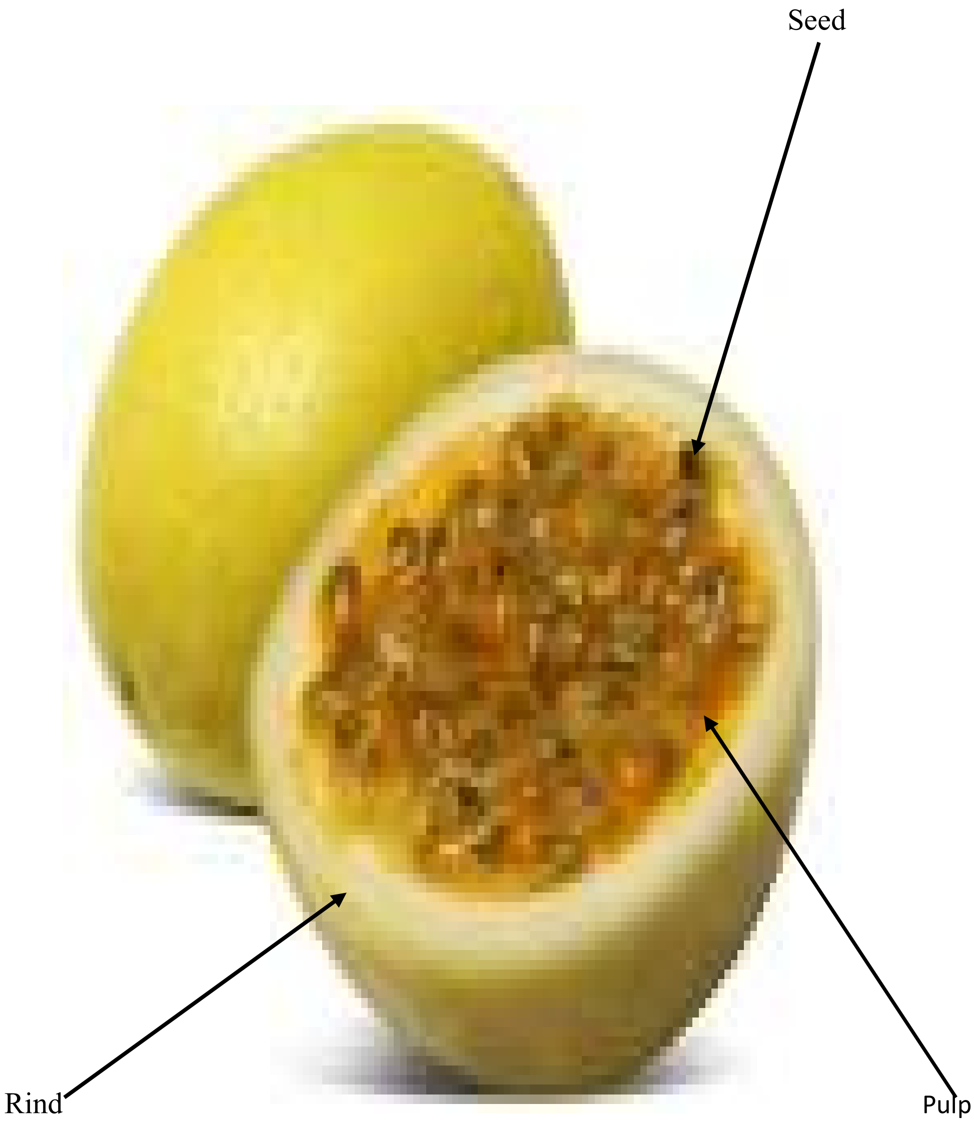

Plate 2.3: *Passiflora edulis* var. *flavicarpa* (Ripe and cut fruit)
Magnification × 1

2.3 Potentials and uses of Passion fruit

Passion fruit has multiple uses as human food, raw material for confectionery and pharmaceutical industries. The fruit juice is a source of natural concentrate and is noted for its unique, exotic and appealing flavour that has been described as musky, guava-like, sub acid to acid in nature. The yellow PF type is more aromatic and tart which makes it more appealing to juice and wine industries. The pulp may be used fresh , canned or bottled. The PF juice contains free amino acids such as argininine, aspartic, glycine, leucine, lysine, Proline, threomine, tyrosine and valine. The carotenoids, flavonoids, alkalnoids and starch are 1.2, 1.1, 0, 01 and 0.7% respectively (Morton, 1987; FAO, 1988; Joseph-Adekunle, 2006). The young leaves, flowers and dried rind when boiled make excellent tea with therapeutic and tranquilising effects on the nerves (Morton, 1987). The pharmaceutical potential needs to be exploited with the current revival of interest in herbs and plant based medications. It is reported that a glycoside called Passiflorine from *Passiflora incarnate* L. is gaining popularity as a sedative or tranquiliser in Europe (Gachanja and Ochiengi, 1988). Some Passion species have great importance as a genetic resource, due to great production potential of being able to adapt to drier weather conditions and production of fruits with characteristic nutritional qualities (Santos *et al*., 2012, 2016). For instance according to Queiroz (2011), *P. cincinnata* plants were used as a source of pathogen-resistance for same-genus species grown in irrigated fields, fruit production in farming system and ornamental or medicinal purposes. The superior types can be grown under rain-fed conditions while to a lesser extent, other species like the sweet passion fruit (*Passiflora alata* Curtis), the breath passion fruit (*Passiflora nitida* Kunth), the shark passion fruit (*Passiflora cincinnata* Mast.) are cultivated for their culinary, medicinal, or ornamental properties (Santos *et al*., 2016).

2.4 Environmental Requirements of Passion Fruit

The PF is a tropical plant and requires minimum well distributed rainfall of between 750-1250 mm per annum (FAO, 1998). It is sensitive to moisture stress but could have fair drought tolerance. Water stress can result in poor fruit set, fruit drop and vine defoliation. High humidity on the other hand had been reported to increase susceptibility to leaf and fruit diseases (Morton, 1987).

Passion Fruit can thrive on wide range of soils except heavy clay and water logged condition. A slightly acidic sandy loam is preferred though alkaline soils with adequate micronutrients can also support PF growth (Jackson, 1986; Morton, 1987; Knight and Saul, 1994). Passion Fruit cannot tolerate extremities of temperatures; these can result in changes of a range of morphological characteristics. In New Zealand the average maximum temperature of 24^{o}C in summer (January) and minimum of 14^{o}C in winter (July) is required (Jackson, 1986). However, in Nigeria, most arable and tropical crops thrive under minimum and maximum temperatures of between 22^{o}C and 24^{o}C and 29^{o}C-32^{o}C (Olasantan, 1988; Makinde and Bello, 2009). Wind tolerance in PF is very poor as they tangle easily as such; the vines need support and protection from wind (Menzel *et al.,* 1986).

Passion flower or fruit's growth and flowering are affected by host of environmental factors. The growth, the longevity and the yield of the plants are influenced by temperature, relative humidity, light intensity and precipitation under hot and humid tropical condition. Biological processes, such as flowering, fertilization, fruit formation, maturation and fruit quality are all temperature dependent. The most favourable temperatures for the growth of the plant range between 21 and 25°C and best between 23 and 25°C. However, PF can be successfully cultivated in temperatures between 18°C and 35°C. It is reported that lower temperatures slow the growth, reduce the nutrients uptake and fruit production of the plant. On the other hand very high or very low temperatures affect fruit bearing. Fruit maturation at intermediate temperatures of 23°C to 28°C, is 60 days, while lower temperatures (23°C) and higher (33°C) the period was 75 days. The seed germination period is also temperature dependent; germination period is shorter in hotter season than in the coldest months (Joy, 2011).

Another key factor that has significant influence on performance of PF is the fertility of the soil, quantity and quality of fertiliser applied. A complete fertiliser has as part of the formulation these three primary elements - nitrogen (N), phosphorus (P) and potassium (K). Optimum fertiliser rate is that which produces maximum yield, leaves no excess or deficit of any nutrient and which prevents any nutrient mining (Sema and Maiti, 2006).

It is reported that Passion Fruit thrives well in heavy sandy loamy soil with pH of 6.5

-7.5, rich in organic matter and with less salt content (Damato *et al*., 2005). On the other hand, a fertilizer that supplies N, P and K in near-equal quantity with essential micronutrients is adequate for PF. Application may be in August or September and November or December at the rate of 49 kg P and 29 kg K per hectare for vegetative growth phase. However, 97 kg N, 17 kg P and 117 kg K per hectare applied in split doses throughout the growth period have been recommended (Jackson, 1986; Knight and Sauls, 1994).

Optimum nutrient supply is a pre-requisite for an efficient nutrient management. The optimum fertilizer requirement is that with no excess or deficit of any nutrient, prevents any nutrient mining, minimizes off-site movement of nutrients and produces maximized fruit yield. Macronutrient removal by a 20 t/ha PF crop was reported to be 55 kg/ha N; 6 kg/ha P; 78 kg/ha K; 6 kg/ha S; 5 kg/ha Ca and 4 kg/ha Mg (Joy, 2011). Sema and Maiti (2006) in determining fertiliser needs in PF reported that the valid approaches concerning methods of determining the fertiliser requirement are through survey of fertiliser practices adopted in high performance PF vines, nutrient removal by fruits, field response studies, regression modelling for soil fertility and leaf nutrient composition, vis-à-vis fruit yield data among others. The nutrient removal or replacement approach described by Sema and Maiti, (2006) considered removal by (i) the fruit, including flesh skin and seed (ii) the leaves (iii) the roots and (iv) the nutrient loss from leaching, erosion and soil fixation. They stated that from 1500 plants spaced at 2 m x 1.5 m with fruit yield of 37 t/ha, the nutrient removal pattern on the whole plant (including fruits) were: 202.5 kg N; 17.4 kg P; 184.2 kg K; 151.6 kg Ca; 14.4 kg Mg; 25.0 kg S; 770.4 kg Fe; 2810.2 g Mn; 198.7 g Cu; 316.9 g Zn and 295.8 g B. The amount of computed nutrients removed by fruits were: 44.5 kg N (21.7% of total removal), 6.9 kg P (39.6%), 73.8 kg K (40.1%), 6.7 kg Ca(4.4%), 4.0 kg Mg (28.1%), 88.0 g Fe (11.4%), 180.1 g Mn (6.4%), 64.0 g Cu (32.2%), 108.1 g Zn (34.1%) and 37.8 g B (12.8%). These values suggest the nutritional requirements of PF.

2.5 Propagation and Agronomic Practices of Passion Fruit

Passion Fruit seedlings are raised from freshly extracted seeds and they readily germinate within 2-3 weeks after sowing. The seeds are planted on beds or pots filled with fertile soil, moistened and placed in shaded area away from direct sunlight at a depth of 1 to 2 cm. Seedlings are potted individually in small polythene bags as soon germination is established, although vegetative propagation is possible (Jackson, 1986; Morton, 1987). To propagate vegetatively, selection of vines from growing area is based on overall vigour; consistent flowering and fruiting, fruit size and flavour, time of ripening and disease resistance. Cuttings are made from tips of virus-free matured laterals after growth flush. Rooting of cuttings can be hastened by hormone treatment (Morton, 1987; McCain, 1993).

The seedlings are transplanted to the field when 20-25 cm tall. The roots of the seedlings are pruned two weeks before transplanting (Morton, 1987). The field is usually well prepared and enriched organically one month in advance. Spacing varies depending on the locations. For instance, in Venezuela it is reported that largest yield of Passion Fruit was obtained when the seedlings were spaced at 3 × 3 m intervals. In South Africa, the Purple form, planted at a spacing of 2.5 × 2.5 m in the cool areas and 3.5 × 3.5 m to 4.5 m in warm areas gave the highest yield (Gurnah and Gachanja, 1984). In Kenya however, spacing at 3 m × 1.8 m gave the highest yield (Gurnah and Gachanja, 1984). Passion Fruit vine is indeterminate in growth and so a great deal of flexibility is expected in spacing (McCain, 1993; Gachanja and Gurnah, 1984).

2.5.1 Trellis Types for Supporting Passion Fruit

Passion Fruit is a vigorous perennial vine that is naturally supported on stakes by tendrils. At the commercial level, the vines are trained on wire trellis at least 2.0 m high since the vines perform poorly when sprawling on the ground. The support mechanism comprises of easy to construct assemblage of posts and wires. Different types of trellis have been employed to carry the fruit-bearing curtains. The simplest form is the single-wire fastened over two posts. Others are double-wire and cross-wire assemblies. Twines are loosely tied to the base of the seedlings and the excess length of twine tied to the wire. The plant is trained up to the trellis by means of the twine string. The laterals and leaders are allowed to hang from the trellis to form the fruiting curtain (Jackson, 1986; Knight and Sauls, 1994; Joseph-Adekunle, 2006). The importance of the trellis as support mechanism has influence on the fruit yield. Santos and Gilreath (2006) reported that a combination of single-wire line or double-wire lines and N fertilizer application resulted in higher number of marketable fruits per plant. Smart (1985) stated that trellising is a common practice in the viticulture and it influences the microclimate which has implication in causing alteration in growth, yield and fruit composition.

2.5.2 Cultural and Maintenance Practices of Passion Fruit

In a Passion Fruit orchard or plantation, maintenance practices such as pruning, weed control and irrigation are of importance. Pruning is an important maintenance practice with most horticultural or plantation crops. It is practised based on the understanding of the growth and morphology of the crop. Pruning of the laterals of Passion Fruit when too low, dense, tangled or weak as well as the tendrils is an important management practice (Gachanja and Gurnah, 1980; Opeke, 1982; Jackson, 1986). The pruning encourages renewal of fruiting curtain and subsequent productivity. It is usually carried out in September or October before the commencement of growth flush (Gurnah and Gachanja, 1980).

Passion Fruit rows are kept weed-free by shallow cultivation and or planting grass strips or green manures between rows where rainfall is sufficient. In Kenya, small scale growers of PF intercropped with pigeon pea and beans in order to distract insects from invading the Passion plant during flowering stage and also to keep rows weed free. The PF plant is prone to attack from a host of insects, nematodes and disease organisms (Morton, 1987; Thorp *et al*., 2006). The vines will continue to flower and fruit with adequate irrigation. A critical period of highest water need is when fruits approach maturity, and deficiency has been reported as cause of fruit shrivelling and premature fruit drop (Gurnah and Gachanja, 1980; Menzel *et al*., 1986; McCain, 1993).

2.6 Pollination, Flowering and Fruit set in Passion Fruit

Correlation exists between floral traits such as form, colour and scent that suggests the presence of a 'broad flower pollination-syndrome'. Tropical plants at low densities are often pollinated by trap-lining animals. The lowland rainforest specie *Passiflora vitifolia (*Darren, 2014; Tropical plants, 2019*)* of the family *Passifloraceae* was reported pollinated by trap-lining hermits (Vanderplank, 1991; Lorenzi *et al.,* 2000; Lindberg, 2010). The white-bearded hermit was reported as the primary pollinator of *Passiflora*s in the Peruvian Amazonas. This was judged from the influence of flowering pattern on pollinator's visitation and the subsequent fruit set. The number of open flowers on the vine determined the frequency of hermit's visits per hour but the arrival time of the first hermit after flower opening which was not influenced by numbers of open flowers, but subsequent fruit set of about 24 % was obtained (Snow,1982). Genetic incompatibility resulted in early fruit abortion in newly formed fruits and later abortion was mainly due to fruit parasitism, although extreme high temperature has also been reported as contributor (Knight and Sauls, 1994; Lindberg, 2010).The most effective pollinator of Passion Fruit flower is the solitary carpenter bee that resembles bumble bee. Other pollinators are bees, humming birds and wind although less effective. Hand pollination has also been reported and this increased the fruit size but is expensive. A lot of intricacies surround the success of pollination such as the curvature of the style in the flower; the stickiness of the pollen and the pattern of the rainfall. If the rains occur in less than two hours after pollination, there will be no fruit set. In Fiji, hand pollination is employed with about 600 flowers being pollinated per hour, 70% fruit set is achieved and 60% reaching maturity (Morton, 1987; McCain, 1993).

The fruit attains maturity in 8-12 weeks after fruit set. Developing fruit remains green until fully matured then there is a rapid change in colour from green to Yellow within few days. Passion Fruit attains full maturity 15-18 months after transplanting and full harvest in 24 months (Joseph-Adekunle, 2006).

2.7 Harvesting, Post Harvesting Handling and Fruit Quality of Passion Fruit

The most common mode of harvest is to allow the matured fruit fall to ground and collected every one to three days or once in a day if the fruit is for export. Also, fully ripened fruits may be picked from the vines although this may have “woody taste” (Jackson, 1986).

Passion Fruit stores well at room temperature and has higher juice percentage compared to other storage methods. Unripe Yellow Passion Fruit can be ripened and stored at 20°C with relative humidity of 85% to 90%. At higher temperature (30°C), rapid ripening sets in and the fruit can be prevented from wrinkling and preserved for one month by coating with paraffin and kept at 5°C to 7°C and 85% to 90% relative humidity (Morton, 1987; Gama *et al*., 1991; Knight and Sauls, 1994). The yellow and purple PF contain ascorbic acid with the purple variety having a slightly higher content. Passion fruit is a high acid food with pH of approximately 3.2 due to the predominance citric acid (about 93-96 % of total) and malic acid (3-6 % of total) acids. Passion fruit edible portion contains about 14.45 g sugar/100g, including fructose, glucose and sucrose, together with seven others in trace amounts. The unique taste of PF juice is due to acids and sugars contents which serve as a preservative nature for the tropical fruit. The purple PF has a higher sugar : acid ratio of 5:1 compared to the yellow with 3:8 so the purple PF is generally sweeter than the yellow passion fruit. Passion fruit is high in potassium, vitamin A, vitamin C, niacin and fibre and it is low in sodium, cholesterol and saturated fats (Joy, 2011).

Despite the high nutritional status of PF, it is subject to post harvest loss if not handled properly. Arjona *et al*., 1992 reported that there was a rapid deterioration of external appearance and/or high weight loss of PF at 5 and 15°C for stored yellow passion fruit. Fruit stored for 15 days at 10°C had the least surface shrivel and weight loss. Also, soluble sugars were maintained at a higher level at 5°C and 10°C than at 15°C while sugar loss was notable at 15°C. Storage at 10°C for 15 days appeared feasible for maintaining quality in yellow passion fruit

2.8 Statistics on Production, Consumption and Prospect of Passion Fruit Industry

Information on production statistics of Passion Fruit (PF) is poorly documented in literature. The production of minor tropical fruits was about 15 million tonnes per year, which is 24% of the world total tropical fruits production in year 2000 (FAO, 2003). Minor fruits like litchis, durcam, rambuttan, guavas and PF are traded mostly at regional levels. Although internationally there are no sufficient details as to global figures but regionally, they are becoming popular (FAO, 2003). In 2002, Brazil, Ecuador and Columbia were the leading producer of PF in the world with 66%, 12% and 11% of planted land area of PF respectively. In Brazil, the yellow passion fruit accounted for 95% of the passion fruit-cultivating area, owing to the quality of its fruits, vigour, yielding , juiciness (Meletti and Brückner, 2001), and the consumer's choice. However, other lesser types of passion fruits together account for less than 5% of the home market, thus indicating their regional importance and limited commercialization (Meletti *et al*., 2005). Production figures of PF in some locations showed potential high yield and increased cultivation. According to Santos *et al*., 2016, in Brazil, the preference yellow passion fruit is evident in the number of states where it is cultivated, making Brazil the largest producer of passion fruit in the world.

According to Piza Junior (1998), in south eastern Brazil, passion fruit is one of the eight most cultivated species of fruit, thus contributing to value small producers for their work, as well as increasing their income. Among fruits, it has been considered an attractive farming choice since it provides a fast economic return, and a chance of an income distributed more evenly throughout the year.

In New Zealand, yield could be between 3 t/ha and 7 t/ha, in Quail Mountain, between 20 t/ha and 40 t/ha, in Brazil between 20 t/ha and 55 t/ha and in Kenya over 30,000 t/ha (Thorp *et al*., 2006). Hafner *et al*., (2013) reported that the production figure has increased tremendously in Ecuador, Brazil, Columbia to 250,000 t/ha, 450,000 t/ha, 30,000 t/ha respectively. The demand for Passion Fruit in United States is estimated 2721.552 tonnes annually (Alabi, 2010). However, in 2014 Brazil became the largest global producer of Passion Fruit with 823,284 tons (FAOSTAT, 2015). The Northeast region and Bahia are the largest producer states accounting for about 73% of Brazilian Yellow Passion Fruit (IBGE, 2015).

The Yellow Passion Fruit (*Passiflora edulis* var. *flavicarpa*) and the Purple variety (*Passiflora edulis* var. *edulis*) differ in their pH and starch content. The Yellow variety has a pH of 2.8, 0.06% starch and 8.7% amylose content compared to the Purple variety with a pH of 4.2, 0.74% starch and amylose content of 5.8%. (Sema and Maiti, 2006; Joy, 2011; Vieth, 2013; Faber and Vieth, 2014). The boiled juice is used in making sauces, gelatines, desserts, candies, ice-cream, cake icing, cake-filling and cold fruit soup for cocktails. In Australia, PF juice is added to yoghurt, and in South Africa, it is blended with milk and alginate (Morton, 1987; Sitthinwong *et al*., 2001; Britto *et al.,* 2005). In Italy, PF commands high price and is sold mostly during Christmas holiday to add variety to their rich dinner (FAO, 1998).

In Brazil, pectin is extracted from the Purple variety and the outer skin yields 1.4 mg/100 g anthocyanin pigment, pelargonid i-3- diglucoside and some other tannins as industrial dyes. The seeds yield oil of commercial value (23%) which has both edible and industrial uses like sunflower and soybean. In Fiji, about 13,000 litres of oil are obtained annually from Passion Fruit seeds. The oil which is low in saturated fatty acids (about 84%) is in increasing demand by cosmetic industries. Yellow Passion Fruit, (*Passiflora edulis* var. *flavicarpa*) has become increasingly popular in the United States of America as a tropical fruit juice commodity, and is mainly imported from Brazil and Ecuador. The juice can be extracted for fresh consumption or boiled to syrup which is used in making sauce, gelatin, dessert, jellies, jams and candies. The fruit is known for its natural sweet taste with an appealing guava-like musky and sub-acid flavour. It contains vitamins A and C, carotenoids and polyphenols (Otagagi and Matsumoto, 2012).

Apart from the nutritional attributes, some researchers have indicated the health benefits of Passion Fruit, especially its anti-cancer properties that show promise. The non-nutritive phytochemicals, carotenoids and polyphenols contained in Passion Fruit have been found to inhibit cell proliferation of leukaemia and induce apoptosis. The carotene content is high and does not contain hesperidin, naringin and limolin which are bitter compounds. The concentration of minerals like sodium and potassium in Passion Fruit is high compared to other fruits but the concentrations of calcium and magnesium are very low (De Neira, 2009; Matsui, *et al.,* 2010).

2.9 Organic Production System

According to USDA (1980), organic farming is defined as production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. This definition focuses on the concept of soil as a living system that develops and regulates the activities of beneficial organisms which are central (Lampkin, 1990). Organic farming is an approach where the aim is to create an integrated, humane, environmentally and economically sustainable production system. It is a practice that sustains soil health and ecosystems by relying on biodiversity, ecological processes and progress of innovative health sciences. Although organic farming avoids or restricts the use of agro chemicals, the use of modern machinery, recommended crop varieties, certified seeds, innovative methods of organic waste recycling and residue management is encouraged (Altieri, 1987).

Organic management practices combine traditional conservation farming methods with modern technologies with avoidance or exclusion of synthetic agrochemicals with emphasis on building up the soil with compost additions, animal and green Organic Fertiliser, controlling pests naturally, rotating crops and diversifying crops and livestock. The most common pesticides include microbial agents, botanical insecticides, oils, soaps and diatomaceous earth (Altieri, 1987; Reganold, 1989).

Organic farming is advantageous over the conventional farming in that the rate of nutrient release is slow compared to the conventional in which the fertilizers are soluble and nutrient elements are released upon application to soil (Tillman, 1991; Matson, *et al.,* 1997; Drinkwater *et al.,* 1998). Reganold *et al.* (2001) reporting on comparative five years study of organic, conventional and integrated apple production system reported that the organic and integrated systems had higher soil quality and potentially lower negative environmental impact than the conventional system. When compared with the conventional and integrated systems, organic system produced sweeter and less tart apples, higher profitability and greater energy efficiency. Fruit tissue nutrient analyses indicated some inconsistencies; but at harvest and post storage the organic apples were firmer. Organic farming system was ranked first in environmental and economic sustainability, followed by the integrated farming system, with the conventional farming ranked last.

2.10 Organic Fertiliser Application as a Critical Component of Nutrient Cycling in Organic Crop Production

Decline in soil fertility is a major problem contributing to low crop yield in most tropical and subtropical regions of the world (Bationo, *et al.,* 2011; Joy, 2011). This is because nutrient removal usually exceeds nutrient addition in manures and fertilizers. Although crop yields remained relatively constant over the years, soil productivity was reported to decrease by 40% due to decreased soil organic matter and fertility (Ogunwale *et al*., 2005).

Low agricultural production in low input systems in the tropics relies largely on nutrient cycling and the maintenance of soil fertility through biological processes. Nigerian soils like other tropical soils lack adequate plant nutrient (Hauser and Kang (1993; Ogunwale *et al.*, 2002). However, organic amendments could have favourable effects on soil by improvement of the soil structure, increase water holding capacity of sandy soils with addition of organic matter.

Consequently, application of organic materials has potential to increase plant yields to an extent above that based on application of mineral fertiliser with equivalent nutrients (Avnimelech, 1986; Broadbent, 1986; Sims, 1996; Atiyeh *et al.,* 2000). Organic Fertiliser amendments to soil have recorded success with some tree crops like teak (Titiloye, 1982) and coffee (Obatolu, 1991). Organic agriculture has been suggested as a mechanism to attain success in the present challenges related to the need for sustainable production methods and high quality produce that can enhance participation in global organic produce markets (Reinjntjes, 1992).

The rates of mineralization of N and P in animal manures are usually higher than in soil organic matter and can vary greatly depending on the nature of the material, storage condition prior to application and climatic condition. Crop residues, composted municipal wastes and sludge are among other kinds of organic wastes applied to soils.
Amundson and Jarrell (1983) found that the value of the N in metric tons of aerobically-digested sludge was equivalent to 24-37 kg N in form of NH_4SO_4. Organomineral fertiliser from composted sludge had beneficial effects on microbial biomass and activity which lend support to using this type of sludge (Selivanovskaya *et al*., 2001). The C/N ratio is a useful tool in predicting N mineralization in crop residues (Broadbent, 1986; Bationo et *al*., 2011).

Globally, the practice of organic agriculture is still very low in comparison with the conventional agriculture. Organic farming has not witnessed elaborate research and development backup compared to conventional farming. There is little experimental evidence that organic nitrogen and phosphate fertilisers are inferior to inorganic fertiliser supplying equal amounts of nutrients for crops grown out door (Lombin *et al.,* 1991). Organic farming incorporates the use of animal manure, compost, cover crops, green manure and organic matter as sources of nutrients. The challenge is that these organic fertilisers vary in their composition, depending on the composting method and the source of composting materials. The main nutrients are nitrogen, phosphorus, potassium, and a host of micro nutrients (Lombin *et al.,* 1991). Sridhar *et al*. (2001) observed that the Pacesetter Organomineral fertiliser (Type A) contained 2.58% N; 1.10 % P; 0.68%; 3.62% Ca; 0.18% Mg; 276.0 mg/kg Zn, 25.0 mg/kg Cu and 32.0 mg/kg Mn per 100 kg fertiliser. Adeoye *et al*. (1993) observed improved yield and quality of maize fertilized with Pacesetter Organomineral fertilizer with accompanying productive residual impact on soil fertility status. Research findings have reported soil qualities like pH, available nutrients, texture, organic matter content and water relationships to have direct effects on crop growth and development (Hornick, 1992; Olubode and Fawusi 1998; Aruleba and Fasina, 2004). Damato *et al.*

(2005) in their work on the evaluation of effects of organic fertilisers on development, production and fruit quality of sweet Passion Fruit *(Passiflora alata* Dryland) showed better results with 5 kg wet cattle manure per plant. There was better juice quality, larger number of fruits and larger production. Britto *et al*. (2005) had similar trend when sheep and poultry manure fortified with potassium was applied to YPF. It was reported that YPF developed adequate attributes for consumption when poultry and sheep manure combined with potassium doses were applied.

The statistics of inorganic fertilisers required in Nigeria for 1985-1987 periods were put at 1.2 million tonnes which were met in 1988 by increased supply which increased to 2.65 million tons in 1994. However in 1995 there was a drastic reduction to 835,000 tons and had been maintained since then (Obigbesan, 1999; Omueti *et al*., 2000). The implication of this is that the average farmer has no access to this important resource of production and as such, necessitates alternative sources of maintaining the soil fertility status. The high prices of mineral fertilisers, increasing scarcity with degrading effects of the fertilisers and attendant declining soil fertility call for urgent alternative intervention like use of organic fertilisers.

The benefits of organic fertiliser use include improvement of soil structure, porosity and density for plant root environment. Others are increased infiltration and permeability of heavy soils, thus reducing erosion and run off. There is improved water holding capacity thus reducing water loss and leaching of both macro and micronutrients in sandy soils. Apart from these, organic fertilisers ensure suppression or control of certain soil-borne plant pathogens and weed seeds. Application of organic fertilisers results in supply of significant quantities of organic matter and improved cation exchange capacities of soils and growing media (Franciosi *et al*., 2001).

The use of organic fertilizer or compost however demands some caution especially with respect to the composting and processing of the organic raw materials. The time, equipment and land must be appropriate and adequate while the emission of ammonia, carbon dioxide, nitrous oxide and other volatile compounds especially in the early stage of the process which can be hazardous to health must be monitored and manage aeration and moisture throughout the composting process. Run off from the compost piles must be controlled to prevent movement of nutrients to ground or surface water (Winblad and Kilama, 1980; Obeng and Wright, 1987; Franciosi *et al*., 2001; Strauss *et al.,* 2003).

2.11 Constraints to Passion Fruit Cultivation in southwest Nigeria

Ndang *et al.,* 2017 identified soil types as major constraint to Passion Fruit production. They stated that the most appropriate method in tackling nutrients constraints In commercial Passion Fruit production as "using leaf analysis based on fertilizer scheduling" The appropriate leaves include the fourth axillary leaf from the growing tip of a fruit bearing shoots or alternatively leaves with an axillary flower bud. Each of the sampling material is used to diagnose and establish specific nutrients problems.

In Passion Fruit, identification of specified leaf age is not easy, except by labelling the shoots because PF is a climbing vine with indeterminate growth. The leaves that correspond to specific phenological stages are usually sampled without prior labelling. They are identified as leaves with axillary flower buds that open within next 24 hours. These readily identifiable buds are 5 cm long, with petals that are just visible and beginning to open. These axillary buds are the most sensitive to different fertiliser treatments, but are not present all the year round. The second type of leaves are the recently matured ones and located in third or fourth position relative to the stem apex and from central fruit bearing shoots.

Results from studies have shown that PF vine parts possess varying critical nutrient concentrations. High Nitrogen fertiliser supply is reported to increase total N concentration of new growth from 1.75 to 7.03%. In the youngest fully expanded index leaves and next 9 older leaves from 1.56 to 7.98% N; in older leaves from 1.37 to 6.86% N; in the stems, from 0.72 to 4.13% N and in the roots from 1.38 to 3.60% N.

Increase in critical ranges of N concentrations in index leaves from 1.5 to 8.0% had been. The critical ranges of N concentration in index leaves using 95% of maximum growth were: 6.0 to 8.0%N for vine extension, 6.3 to 7.8% N for number of nodes, 4.3 to 6.6% N for number of leaves, 5.0 to 7.2% N for leaf area, 4.4 to 7.1%N for leaf dry weight and 5.5 to 8.6% N for stem dry weight. They stated that to make prediction for ensuring the best overall growth and productivity, critical range of 4.4 to 5.5% N in the index leaves is recommended (Sema and Maiti 2006; Ndang *et al.*, 2017). Passion Fruit is a major organic produce like vegetables, ornamentals and fruits with increasing demand and great potentials for cultivation under the suitable climatic and soil conditions of Southwestern Nigeria (Sims, 1996; Aiyelaagbe and Afolabi, 2005; Britto *et al.,* 2005; Damato *et al.*, 2005).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Location and Description of the Experimental Sites

Studies were conducted in 2009, 2010, 2011, 2012 and 2016 at the Federal University of Agriculture, Alabata, Abeokuta (FUNAAB) (Latitude 7^o $14^|$ 8.034 NS, Longitude 3^o $26^|$ 13.914 EW and altitude 131 m asl), Ogun State, Nigeria. There were three pot experiments at Abeokuta and one field experiment carried out at JOSADI farms, Siun (Latitude 6^o $57^|$ 47.313 NS, Longitude 3^o $31^|$ 49.707 EW and altitude 107 m asl), Obafemi/Owode Local Government Area, Ogun State, Nigeria. The two locations lie within the rainforest-savannah transition zone and are characterised by bimodal rainfall pattern (Plates 3.1 and 3.2). The wet season is from February to October and dry season from November to January (Aiboni, 2001, Google, 2017).

The mean annual rainfall between 2009 and 2012 ranged between 97.0 and 133.26 mm; and in 2016 was 54.7 mm. The mean relative humidity ranged between 78.2 and 82.6% in 2009-2012 and 61.0% in 2016. The mean maximum temperature ranged 31.7 and 32.3^{o}C while mean minimum temperature was between 22.3 and 23.2^{o}C in 2009-2012; and 32.7 and 23.3^{o}C for maximum and minimum temperatures in 2016 (Tables 3.1 and 3.2).

The site for the field experiment had been previously cropped to cassava and left fallow for five years before commencement of the study in 2009. The soil of the experimental site belongs to the Egbeda series of the order Alfisol and sub-order Udalf. The soil is coarse to fine textured, clayey, well drained and sedimentary with the colour varying from brown to orange (USDA, 1938; Smyth and Montgomery, 1962).

3.2 Source of Organic fertiliser and Passion Fruit seedlings

The Organic Fertiliser (N-0.78g/kg, P-12mg/kg, K-0.07cmol/kg) was procured from Ondo State Waste Management Board, Akure. It was prepared from materials collected from major

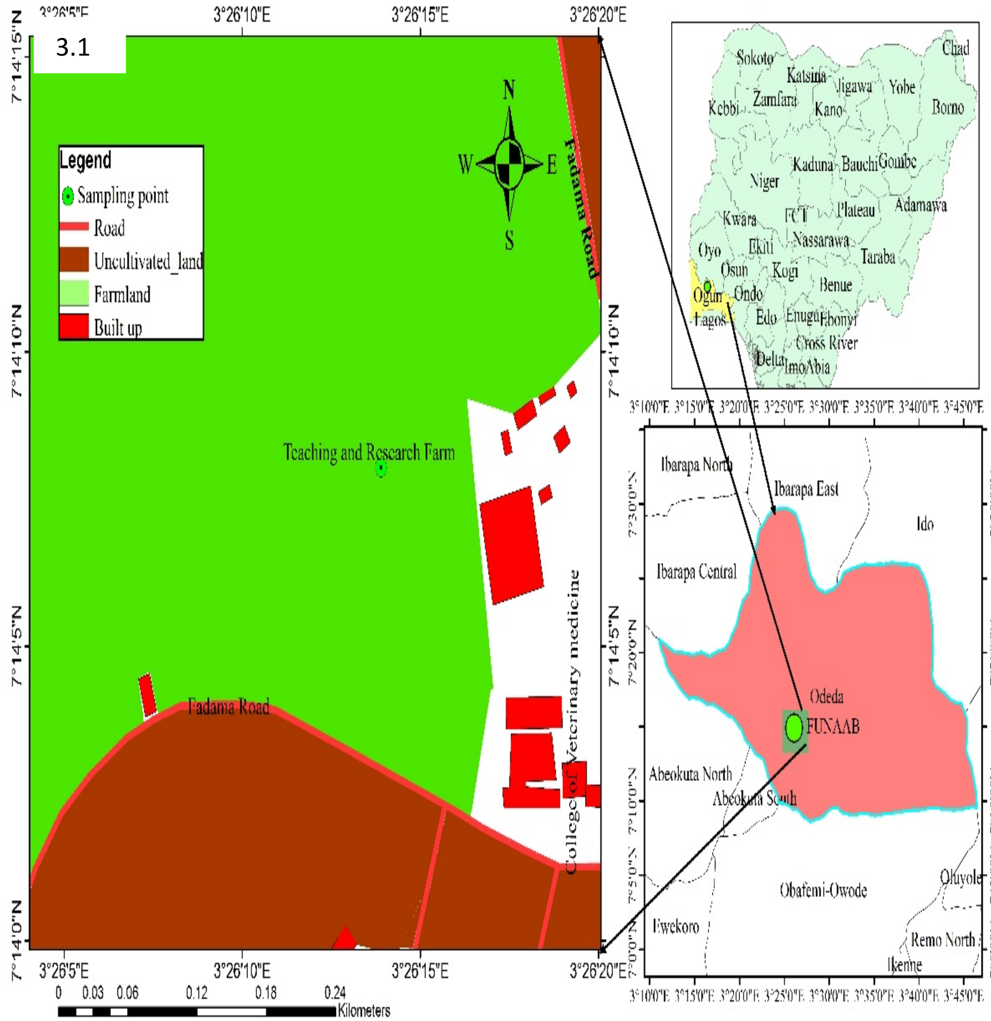

Plate 3.1: Map of Federal University of Agriculture Abeokuta (FUNAAB), Ogun State showing the location for Pot experiments

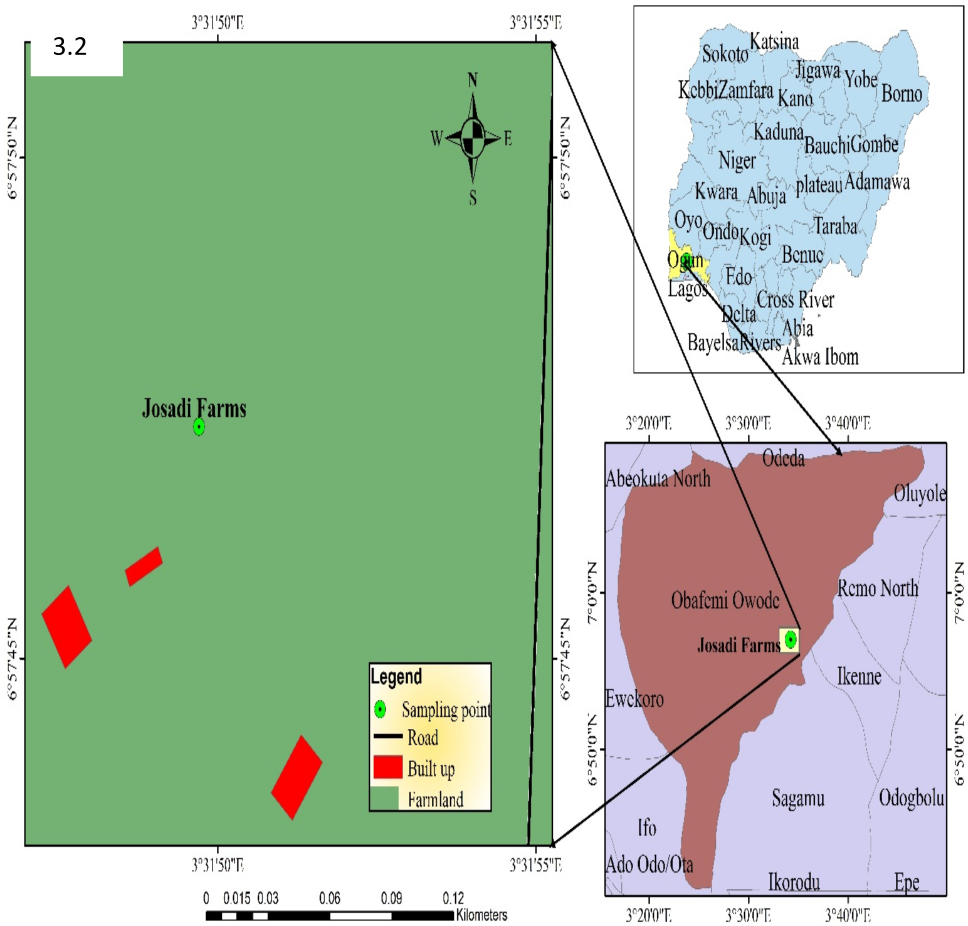

Plate **3.2:** Map of JOSADI FARMS Siun, Obafemi Owode LGA. Ogun State showing the location for field experiment

Table 3.1: Weather data from 2009 to 2011at Abeokuta, Ogun State

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
							2009							
Max (T oC)	32.7	33.8	34.4	31.7	32.0	31.2	23.5	NA	NA	NA	32.9	33.2	-	31.7
Min (T oC)	22.0	24.0	23.5	23.6	22.5	22.7	22.4	NA	NA	NA	22.0	23.2	-	22.9
RF (mm)	0	59.1	67.3	274.0	286.8	258.0	221.5	NA	NA	NA	55.7	0	1222.4	101.9
RH (%)	70.1	72.8	80.5	82.3	80.0	83.5	88.5	NA	NA	NA	82.2	79.1	-	79.9
							2010							
Max (T oC)	33.5	36.9	34.0	33.1	32.1	31.0	29.5	29.4	30.5	32.0	31.8	31.9	-	32.1
Min (T oC)	22.7	24.4	24.7	23.8	23.9	23.7	22.3	22.7	22.8	22.5	22.3	22.4	-	23.2
RF (mm)	4.4	41.2	58.9	112.7	169.6	98.3	322.9	266.6	257.6	172.3	94.7	0	1599.2	133.3
RH (%)	80.9	78.3	78.8	78.8	80.5	85.4	87.7	85.9	85.9	81.7	86.0	81.1	-	82.6
							2011							
Max (T oC)	34.3	34.6	34.1	34.2	32.8	30.9	28.9	28.5	30.6	31.2	33.4	33.8	-	32.3
Min (T oC)	20.1	23.1	24.3	24.1	23.3	22.9	20.0	22.0	22.6	22.5	22.4	20.2	-	22.3
RF (mm)	0	139.8	23.9	74.5	73.7	84.5	349.5	88.7	204.1	288.1	3.6	0	1330.4	110.9
RH (%)	65.9	78.7	80.0	76.4	78.9	82.2	84.6	84.7	84.1	79.5	82.0	67.7	-	78.2

Table 3.2: Weather data for 2012 and 2016 at Abeokuta, Ogun State

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Mean
							2012							
Max (T oC)	34.0	33.9	34.3	33.1	32.2	30.8	29.9	28.4	29.6	32.2	33.0	34.8	-	32.2
Min (T oC)	20.0	23.7	23.9	23.9	23.1	23.0	22.2	22.6	22.7	22.1	23.3	22.7	-	22.8
RF (mm)	0	67.2	67.7	80.1	115.3	225.1	155.4	36.3	181.4	184.7	49.6	1.3	1164.1	97.0
RH (%)	75.2	70.5	79.3	79.5	77.3	78.7	80.9	82.6	76.0	77.5	81.9	78.5	-	78.2
							2016							
Max (T oC)	35.4	36.4	34.8	34.2	33.5	30.6	29.7	28.9	30.5	NA	NA	NA	-	32.7
Min (T oC)	20.4	24.2	24.4	24.4	24.3	22.7	22.9	22.7	23.6	NA	NA	NA	-	23.3
RF (mm)	1.03	0	12.5	68.2	226.2	150.5	9.3	8.0	16.4	NA	NA	NA	492.1	54.7
RH (%)		24.3	59.1	72.2	84.4	82.3	83.3	83.3	82.7	NA	NA	NA	-	61.0

Source of tables 3.1 and 3.2: Department of Water Resources and Agro meteorology, College of Environmental Resources Management, Federal University Agriculture Abeokuta, Nigeria. RH: Relative Humidity, RF: Rainfall, NA: Not available markets and dumping sites within the metropolis in the State. The materials were sorted into bio-degradable and non-bio-degradable components. The bio-degradable components were composted in windrow. The matured compost was dried, milled and sieved to obtain the Organic Fertiliser.

The seedlings of the Yellow Passion Fruit were obtained from National Horticultural Research Institute (NIHORT), Idi Ishin Ibadan, Oyo State, Nigeria. The seedlings were raised from seeds of matured fruits in the nursery in polyethylene bags and were about 4 months old at the time of purchase. Other materials used included twines, 14-gauge galvanized wire, posts from *Bambossa sp.* and *Spondias mombin* which were used for construction of trellises for support mechanism. Pots of 16-litre capacity were each filled with 5 kg soil and used for planting in the screenhouse.

3.3 Soil Sample Collection, Preparation and Analyses

Soil samples were collected from the experimental plot at Siun village at the depth of 0-15 cm using soil auger. Thirty core soil samples were taken randomly at different points within the trial field and bulked to form a composite sample for pre-cropping routine analysis. The composite soil sample was air-dried at room temperature and sieved to pass through a 2.0 mm mesh for the analyses of its chemical and physical properties. Post-planting soil analyses were similarly carried out at the end of the experiments. The pre- cropping and post-cropping soil samples were analyzed for pH, organic carbon, total N, available P, exchangeable bases and particle sizes following methods described by Udo and Ogunwale (1986).

3.3.1 Soil total Nitrogen determination

Nitrogen was determined by micro-Kjeldahl method. About 0.5 g of 0.5 mm sieved soil was weighed into digestion flask together with 0.5 g of salt/catalyst mixture of Sodium sulphate and Copper sulphate (ratio 10:1) in 5 ml concentrated Sulphuric acid and digested for about 3 hours (Jackson, 1962; Amin and Flowers, 2004).

The digested solution was made up to 50 ml mark with distilled water and shaken in a back-and-forth manner. Thereafter, an aliquot of the digest was taken and the N content determined by Colorimetric method using Technicon auto-analyser and read with spectrophotometer model Labomed20D at 630 nm vs.

Nitrogen content was calculated stated as follow:

$$\text{Nitrogen (\%)} = \text{Nitrogen (\%)} = \frac{\text{absorbance} \times \text{slope} \times \text{dilution factor}}{10000}$$

where:

absorbance = meter reading of the sample

slope = the value obtained from calibration curve of standards and their absorbances

dilution factor = final volume of digest ÷ weight of soil sample × aliquot

aliquot = volume taken from digested solution

10000 = conversion factor to percentage

3.3.2 Soil total Phosphorus determination

Total Phosphorus was determined by Vanadomolybdate colorimetric method. Precisely, 5 ml aliquot of the digest and 10 ml of Vanadomolybdate reagent were added together in 50 ml volumetric flask, swirled and made up to mark with distilled water. The content of the flask was shaken thoroughly and allowed to stand for 30 minutes after which the Phosphorus content was determined on spectrophotometer at 470 nm wavelength.

Phosphorus content was calculated as stated below:

$$\text{Phosphorus (\%)} = \frac{\text{absorbance} \times \text{slope} \times \text{dilution factor}}{10000}$$

where:

absorbance = meter reading of a sample

slope = the value obtained from calibration curve of standards and their absorbances

dilution factor = final volume of digest ÷ weight of soil sample × aliquot

aliquot = volume taken from digested solution

10000 = conversion factor to percentage

3.3.3 Soil Potassium determination

Potassium in the digest was determined in Flame Photometer. Potassium content was calculated as stated as follow:

$$\text{Potassium (\%)} = \frac{\text{absorbance} \times \text{slope} \times \text{dilution factor}}{10000}$$

where:

absorbance = meter reading of the sample

slope = the value obtained from calibration curve of standards and their absorbances

dilution factor = final volume of digest ÷ weight of plant sample × aliquot

aliquot = volume taken from digested solution

10000 = conversion factor to percentage

3.3.4 Determination and calculation of Ca, Mg, Zn, Fe, Mn and Cu in the soil

These elements are determined in the digest on Atomic Absorption Spectrophotometer (AAS). Calculations were as shown below:

$$\text{Ca and Mg (\%)} = \frac{\text{absorbance} \times \text{slope} \times \text{dilution factor}}{10000}$$

where:

absorbance = meter reading of a sample

slope = the value obtained from calibration curve of standards and their absorbances

dilution factor = final volume of digest ÷ weight of soil sample × aliquot

aliquot = volume taken from digested solution

10000 = conversion factor to percentage

Zn, Mn and Cu (mg/kg) = absorbance × slope × dilution factor

where:

absorbance = meter reading of a sample

slope = the value obtained from calibration curve of standards and their absorbances

dilution factor = final volume of digest ÷ weight of soil sample × aliquot

aliquot = volume taken from digested solution.

3.4 Organic Fertiliser and Plant Samples Analyses

The Organic Fertiliser was analyzed using the wet oxidation (Perchloric acid digestion) method as described by A.O.A.C. (1990). Organic Fertiliser was oven dried at 65°C, ground and 0.5 g weighed into 100 ml Berzelius beaker. Concentrated Nitric acid (HNO_3) 20 ml, 4 ml Perchloric acid ($HClO_4$) and 2 ml concentrated Sulphuric acid (H_2SO_4) were added to the sample under a fume-cupboard. The contents were mixed and gently heated at low to medium heat on a hot plate under Perchloric acid fume-hood, until all the materials were completely digested. The digest was allowed to cool, then washed into 100 ml Pyrex volumetric flask and made up to 100 ml mark with distilled water. Phosphorus and Fe were colometrically determined and Ca, Zn and Mg concentration in the digest by Atomic Absorption Spectrometry.

Similarly, the plant samples for the first and second pot experiments were collected at 15 and 16 WAT, oven dried at 65°C for 72 hours, grounded and analysed to assess nutrient concentrations and nutrient uptake. Plant samples were analysed for their P and K contents according to the procedures of (IITA, 1979). A 5.0 ml Nitric and Perchloric acid mixture (ratio 3:1) was added into 0.2 g of each sample contained in a 25 ml conical flask and left overnight. The plant samples were heated until white fuming stage, the point at which 1.0 ml of Hydrochloric acid and distilled water mixture (ratio 1:1) was added and further heated for 30 minutes before heat was removed. Distilled water was added to the digestum and shaken before cooling down to room temperature to avoid formation of insoluble Perchlorate compounds. The digestum was washed into 50 ml volumetric flasks and made up to mark with distilled water.

3.5 Data Collection and Analyses

Data collection commenced at transplanting and continued at three-week intervals until 15 WAT for first experiment. For second pot experiment, data collection started at 1 WAT and continued at fortnightly until 16 WAT. Data collection for third pot experiment commenced at 2 WAT and continued at two-week intervals until 16 WAT. The growth parameters measured were (i) Vine length measured at 3 cm from soil level to the tip of the longest vine, (ii) Numbers of leaves, laterals and tendrils determined by count, (iii) Vine diameter using digital Vernier caliper and (iv) Leaf area by non-destructive method. The Passion Fruit vine was divided into three segments and 3 leaves selected from each segment and tagged. Each leaf lamina length was measured and the mean value substituted in the equation:

$Y = 11x - 49.2\ (r^2)$

where:

Y= leaf area (cm^2),

x = lamina length (cm),

$r^2 = 0.94$ (coefficient of linear determination) (Aiyelaagbe *et al*., 2005a).

3.5.1: Determination of Foliar Chlorophyll and Dry matter of Passion Fruit seedlings

The foliar chlorophyll content was determined at 12 WAT in second experiment. Five fully recently expanded leaves were selected and chlorophyll content read with Chlorophyll meter model *SPAD 520* (Konica Minolta Sensing Incorporation, Japan). Similarly the leaf chlorophyll content in third pot experiment was determined at 8 WAT using chlorophyll meter model *atLeaf*.

Dry matter yield was determined at 16 WAT for the second pot experiment; and at 8 and 16 WAT for third pot experiment. The data plants were separated into roots, vine, leaves and tendrils and oven dried at 70^{o}C to a constant weight. Analysis for nutrient concentrations in the root and leaf was carried then carried out as described by Jackson (1962). The foliar nutrients concentrations, foliar nutrient uptakes and total nutrient uptakes in YPF seedlings were determined at 16 WAT in procedures described by IITA (1979). The uptake was calculated as % nutrient concentration × dry weight divided by 100 expressed in g/plant

Data analyses were done using Analysis of variance (ANOVA) and significant treatment means separated using DMRT or LSD at 5% level of significance. Correlation and linear regression analyses were done to determine the degree of association and to predict the response of vegetative parameters to Organic Fertiliser application.

3.6 Pot Experiments

3.6.1 Effects of Organic Fertiliser application rates on the growth of juvenile Yellow Passion Fruit

The pot experiments were carried out in the screenhouse of College of Plant Science and Crop Production (COLPLANT) and Horticulture nursery between October 2009 and April, 2010, May 2010 and October, 2010, December 2015 and July 2016.

Soil for the pot experiments was collected from the site of field experiment at Siun via Owode-Egba in Obafemi/Owode Local Government Area of Ogun State. The soil was sieved and 5 kg weighed into each of the 16-litre capacity pots and the Organic Fertiliser at the different rates was then mixed with the soil in the pots. The potted mixture was watered to saturation and allowed to stand for two weeks before transplanting the seedlings at the rate of one seedling per pot. The Organic Fertiliser was applied at 0, 0.5, 1.0, 1.5, 2.0 and 2.5 t/ha (equivalent to 0, 1.25, 2.50, 3.75, 5.0, 6.25 and 7.5 g/pot) for the first experiment to give a total of eighteen treatments combination. Two seedlings were assigned to each treatment. Taking the best rate (0.5 t/ha) from the first experiment, the Organic Fertiliser for the second experiment was added at 0, 0.3, 0.6, 0.9, 1.2, 1.5, 1.8, 2.1, 2.4, 2.7, 3.0 t/ha (0, 0.75, 1.5, 2.25, 3.0, 3.75, 4.5, 5.25, 6.0, 6.75, 7.5 g/pot) based on adequate range (43-55 g) of foliar N for PF defined by IFA (1992) and Prado and Natale (2006). The treatments were replicated thrice to give a total of 36 treatment combinations. The soil for third experiment was collected from the previous field of study. Routine pre cropping soil analysis was carried out and post cropping at 8 and 16 WAT. The soil was sieved and 20 kg weighed into each of the 53 x 33 cm 14 gauge black nursery polythene bags. The Organic Fertiliser was added at 0, 5.5, 11.0 and 16.5 t/ha (0, 5, 10 and 15 kg/plant) based on critical K need of Passion Fruit (IFA 1992; Slack and Dirou, 2004; Prado and Natale, 2006). The Organic Fertiliser was mixed with the soil, watered to saturation and left for two weeks to allow for mineralisation. The Passion Fruit seedlings were transplanted thereafter at the rate of one seedling per pot. Four seedlings were assigned to each treatment as data plant. The treatments were replicated four times laid out in a completely randomised design (CRD).

3.7 Field Experiment

3.7.1: Response of Yellow Passion Fruit to Organic Fertiliser application under field condition at Siun in 2011

Objective: to assess the effects of rates of Organic Fertiliser on growth and yield of YPF

Methodology

Seeds of YPF were extracted from matured fruits and germinated first in the pre nursery in April 2010. They were transferred to the nursery in May 2010 and nurtured till August 2010. The trial site was manually cleared and mapped into three blocks of 162 m^2 each separated by a 2 m alley. Planting holes were dug at inter-row and intra-row spacing of 3 m each. One four-month old seedling of YPF was transplanted into each hole to give a total of 84 YPF seedlings. Seven seedlings were assigned to each treatment (control and each rate of Organic Fertiliser) and three plants were randomly tagged for data collection in September 2010. The seedlings were mulched with dry grasses and plant debris. The seedlings were watered with 0.75 l of water twice weekly during the dry season (November 2010 to February 2011) using improvised drip method with empty polyvinyl bottles perforated at the cap. Twines were loosely tied to the base of the seedling and the top of the wire to train the seedlings to climb on the one-wire support trellis. The best rate of the Organic Fertiliser (0.5 t/ha) from the pot experiments was made a standard and scaled for the field study. The Organic Fertiliser was applied at 0, 0.5, 1.5 and 2.5 t/ha (equivalent to 0, 0.45, 1.35 and 2.25 kg/plant) based on the seedling population of 1,110 seedlings/ hectare in March 2011. The Organic Fertiliser was applied at a distance of 10 cm away from the base of the vine in a 20 cm wide circumference. The Organic Fertiliser was incorporated into the soil as described by Borges and Lima (2003). The treatments were replicated three times and assigned in a RCBD.

Data collection and analyses

Data were collected on the following:

(i) Vegetative growth parameters (numbers of laterals and trusses)

(ii) Reproductive parameters which were numbers of flower buds, flowers, fruits by count and fruit yield (kg/ha).

(iii) Cash Benefit analysis using the local prevailing prices for PF sale. Total costs included non-harvest variable costs (Organic Fertiliser, fuel, labour and water), harvest variable costs (picking, grading, packing and storage) and fixed costs (land, tools and machinery). Projected returns for 5-year productive life of PF were estimated from the fruit yield in the first year. The formula used was:

$P = TR - TC$

where:

P = profitability,

TR = Total Revenue,

TFC = Total Fixed Cost,

TVC = Total Variable Cost

TC = Total Cost = $TFC + TVC$,

$\therefore P = TR - TFC - TVC$

Data collected on vegetative growth and reproductive parameters were subjected to Analysis of Variance (ANOVA) using Genstat 12th edition and significant treatment means were separated using DMRT at $p = 0.05$.

CHAPTER 4

4.0 RESULTS

4.1 The Pre-cropping Soil Properties and the Nutrient Contents of Organic Fertiliser

In the first and second pot experiments, the soil was slightly acidic sandy loam with low % N; moderate available P and Zn. The K was extremely low based on critical levels of the nutrients (0.2-0.5%N, < 3 mg/kg P, 0.12-0.2 cmol/kg K) (Chude *et al.,* 2012) However, the soil for the third pot experiment had high N, P and K contents (Table 4.1). The nutrient contents of the Organic Fertiliser for the pot and field experiments indicated that N and P contents were low but K content and total carbon concentrations were very high (Table 4.2).

4.2 The Nutrient Content of the Organic Fertiliser and Effects on Soil Fertility Status in the Pot Experiments

Organic Fertiliser (OF) applied above 2.0 t/ha increased the N and K status of the soil but the pre-planting available P decreased in the control treatment. The total C and Mg concentration in the soil decreased with or without OF application. The pre-cropping Ca content decreased for control treatments and OF applied at 0.5 t/ha. The increasing rates of OF resulted in increased Ca for OF addition up to 2.5 t/ha. Similar trend was observed for Na up to 2.0 t/ha OF application rate. Magnesium and Cu contents also increased with addition of the OF but Zn content decreased. However, soil Fe content remained stable in pots treated with OF except in control pots (Table 4.3).

Organic Fertiliser addition affected the soil pH as this was changed from acidic to near neutral to neutral. The soil texture was affected by the applied OF with increase in the particle sizes of sand, clay and silt respectively. The OF applied resulted in increased soil fertility.

Table 4.1: Pre-cropping physical and chemical properties of soil collected from field experiment location at Siun, Obafemi/ Owode LGA, Ogun state in First, Second and Third Pot Experiments in 2009, 2010 and 2016

Variables	2009 and 2010 Values	2016 Values
pH in water (1:1)	6.50	6.02
Macronutrients		
N (g/kg)	0.78	3.3
Available P (mg/kg)	12.25	8.68
Total carbon (g/(g/kg)	2.16	14.1
Exchangeable bases (cmol/kg)		
Ca	3.87	2.09
Mg	0.96	0.90
K	0.07	0.17
Na	0.23	NA
Micronutrients (mg/kg)		
Mn	43.80	311.00
Zn	13.42	1.13
Cu	0.27	3.64
Fe	3.65	45.90
Particle size distribution (g/kg)		
Sand	764	814
Clay	60	126
Silt	176	60
Textural class	Sandy loam	Sandy loam

Table 4.2: Chemical properties of the Organic Fertiliser applied in First, Second and Third Pot experiments in Abeokuta in 2009, 2010 and 2016

Variable	2009 and 2010	2016
Macronutrient	Value	Value
Total N (g/kg)	10.00	6.87
Total P (g/kg)	9.87	13.22
Total carbon (g/kg)	22.62	60.4
Exchangeable bases (g/kg)		
Ca	63.75	112.50
Mg	4.31	4.40
K	6.86	36.30
Na	3.97	NA
Micronutrients (mg/kg)		
Mn	230.60	500.00
Cu	43.70	110.00
Zn	169.00	130.00
Fe	15.88	365.00

Organic Fertiliser (Sunshine Organic Fertilizer)
Note: OF obtained were two different batches of production line

Table 4.3: Post transplanting physical and chemical properties of the soil of the Experimental site as affected by Organic Fertiliser application in first pot experiment at Abeokuta in 2009

		Organic Fertiliser (t/ha)					
		0	0.5	1.0	1.5	2.0	2.5
Variables	Pre-transplanting values	Post transplanting values					
pH	6.50	6.80	7.06	7.36	7.38	7.24	7.12
Macronutrients							
N (g/kg)	0.78	1.21	0.24	1.27	1.34	1.77	1.79
Available P (mg/kg)	12.25	0.25	1.16	1.36	1.48	1.58	1.72
Organic C(g /kg)	2.16	0.82	1.03	1.07	1.08	1.24	2.11
Exchangeable bases (cmol/kg)							
Ca	3.87	3.70	3.70	4.12	4.38	4.16	4.46
Mg	0.23	0.03	0.04	0.04	0.04	0.05	0.08
K	0.07	0.52	1.61	12.9	13.0	13.73	12.09
Na	0.96	0.70	1.15	4.41	4.22	.41	2.97
Micronutrients (mg/kg)							
Mn	43.80	44.20	46.62	46.53	46.37	46.00	44.73
Cu	0.27	0.41	0.36	0.46	0.44	0.43	0.40
Zn	13.42	0.26	0.25	0.32	0.31	0.31	0.28
Fe	3.65	2.00	2.90	3.20	3.30	3.40	3.60
Particle size distribution (g/kg)							
Sand	764	870	878	878	884	884	888
Clay	60	48	42	42	42	42	42
Silt	176	82	80	80	74	74	70
Textural class	Sandy loam	----------------------- Sandy loam----------------------					

Soil fertility in the third experiment increased with the application of the Organic Fertiliser (OF). At 8 WAT the % N in the soil decreased from the initial 3.3 g/kg to 1.22 for control treatment and between 2.04 and 3.10 g/kg for the OF rates. The available P, organic carbon, K, Mg, Na, Cu, Zn and Fe all increased with the exception of Mn that decreased at increasing rates of OF. The pH was changed from strong acidic to weak acidic level. Similar trend was observed at 16 WAT for the soil properties with increasing rate of the OF (Tables 4.4 and 4.5).

4.3 Effects of Organic Fertiliser application on vegetative growth of Passion Fruit seedlings in first pot experiment

(a) Vine length

Seedling vine length at 3 WAT showed that seedlings that received OF at 0.5 t/ha had the longest vine although not significantly different from seedlings supplied with 1.5 t/ha (Table 4.6). The vine length of YPF seedlings increased with or without the OF application throughout the period of observation. Yellow Passion Fruit seedlings applied with other OF rates and control had lower values. Over the period of observation, YPF seedlings that were not treated with OF had longest vine length especially at 12 WAT and 15 WAT. This was followed by seedlings supplied with the Organic Fertiliser at 0.5 t/ha at 12 WAT and 15 WAT. Application of OF at 1.0 t/ha and above to YPF seedlings produced significantly shorter vines (Table 4.6).

(b) Vine diameter

Application of the OF at 0.5 t/ha resulted in largest vine diameter at 15 WAT. This was followed by seedlings that received Organic Fertiliser of 1.5 t/ha between 6 and 12 WAT. Conversely, OF applied at 2.0 t/ha and 2.5 t/ha produced YPF seedlings with significantly lower vine diameter. The applied OF had significant effect on vine diameter of YPF seedlings between 3 and15 WAT (Table 4.7).

(c) Number of leaves

At 9, 12 and 15 WAT application of Organic Fertiliser at 0.5 t/ha, 1.5 t/ha, 2.0 t/ha and 2.5 t/ha did not produce significant effects on number of leaves of Passion Fruit seedlings compared with control (Table 4.8).

Table 4.4: Post transplanting physical and chemical soil properties of the third pot experiment as influenced by the different rates of the Organic Fertiliser at 8 weeks after transplanting at Abeokuta in 2016

Variables	Pre- transplanting values	Organic Fertiliser (t/ha) Post transplanting values			
		0	5.5	11.0	16.5
pH (H_2O)	6.02	6.60	6.40	6.30	6.20
Macronutrients					
N (g/kg)	3.3	1.22	2.04	2.81	3.10
Avail. P (mg/kg)	8.68	31.39	103.66	139.68	100.27
Organic C(g /kg)	14.1	16.0	28.4	30.4	36.4
Exchangeable bases (cmol/kg)					
Ca	2.09	2.90	14.80	25.38	29.63
Mg	0.90	1.73	3.09	5.71	7.29
K	0.17	0.52	1.21	1.78	1.98
Na	NA	0.29	0.40	0.38	0.26
Exchangeable acidity (cmol/kg)	NA	0.30	0.40	0.40	0.30
Micronutrients (mg/kg)					
Mn	311.00	301	214	198	171
Cu	1.13	1.97	2.58	2.64	4.04
Zn	3.64	2.95	3.93	4.78	5.48
Fe	45.90	55	147	149	161
Particle size distribution (g/kg)					
Sand	814	846	826	824	814
Clay	126	104	114	104	106
Silt	60	50	60	72	80
Textural class	Sandy loam	------------------- Sandy loam --------------			

NA = Not available

Table 4.5: Post-planting physical and chemical soil properties of the third pot experiment as influenced by the different rates of Organic Fertiliser at 16 weeks after transplanting at Abeokuta in 2016

Variables	Precropping sample	Organic Fertiliser (t/ha) 0	5.5	11.0	16.5
pH (H_2O)	6.02	6.50	6.60	6.80	6.80
Macronutrients					
N (g/kg)	3.3	1.34	2.01	3.68	3.12
Avail. P (mg/kg)	8.68	38.82	163.22	175.07	142.36
Organic C(g /kg)	14.1	18.4	21.6	42.0	34.8
Exchangeable bases (cmol/kg)					
Ca (cmol/kg)	2.09	2.53	18.55	38.82	44.73
Mg (cmol/kg)	0.90	1.45	3.80	6.04	8.11
K (cmol/kg)	0.17	1.14	2.24	2.48	2.23
Na (cmol/kg)	NA	0.33	0.26	0.30	0.34
Exchangeable acidity (cmol/kg)	NA	0.30	0.20	0.40	0.30
Micronutrients (mg/kg)					
Mn	311.0	331	178	191	160
Cu	1.13	1.44	3.20	3.62	3.93
Zn	3.64	3.18	5.49	6.51	6.94
Fe	45.00	57	153	185	153
Particle size distribution (g/kg)					
Sand	814	782	804	800	798
Clay	126	104	102	96	114
Silt	60	114	94	104	88
Textural class	Sandy loam	-----------------Sandy loam-------------------			

Table 4.6: Effects of Organic Fertiliser application on vine length (cm) of seedlings of Yellow Passion Fruit in first pot experiment at Abeokuta in 2009

	Weeks after transplanting					
Organic Fertiliser (t/ha)	1	3	6	9	12	15
0	18.7	48.0	104.7	133.3	166.0	194.3
0.5	20.7	57.7	106.0	121.7	133.9	152.7
1.0	19.0	35.0	67.0	92.7	116.7	127.3
1.5	19.0	53.0	71.3	69.7	76.3	83.0
2.0	16.3	41.3	59.0	68.0	78.7	83.0
2.5	19.0	50.3	71.0	85.0	92.0	101.7
SE	5.1	14.4	26.3	33.0	42.0	50.0

SE = Standard error of mean

Table 4.7: Effects of Organic Fertiliser application on vine diameter (mm) of seedlings of Yellow Passion Fruit in first pot experiment at Abeokuta in 2009

	Weeks after transplanting					
Organic Fertiliser t/ha)	1	3	6	9	12	15
0	10.7	14.7^{ab}	14.7^{abc}	14.7^{ab}	14.7^{bc}	17.0^{bc}
0.5	10.0	17.3^{a}	17.7^{a}	18.0^{a}	18.3^{a}	19.7^{a}
1.0	10.0	13.0^{bc}	14.0^{bc}	15.0^{ab}	15.0^{bc}	19.0^{ab}
1.5	10.3	15.3^{ab}	17.3^{ab}	17.3^{a}	17.3^{ab}	18.7^{ab}
2.0	8.3	10.7^{c}	11.33^{c}	12.0^{b}	12.7^{c}	14.0^{d}
2.5	10.0	13.3^{bc}	14.7^{abc}	14.7^{ab}	14.7^{bc}	15.0^{cd}
SE	1.29	2.14	2.08	1.71	1.63	1.38

Means in a column with same letters are not significantly different at $p \leq 0.05$)

Table 4.8: Effects of applied Organic Fertiliser on number of leaves of seedlings of Yellow Passion Fruit in the first pot experiment at Abeokuta in 2009

Organic Fertiliser (t/ha)	Weeks after transplanting					
	1	3	6	9	12	15
0	7.3	11.0	15.3	16.3	19.3	27.3
0.5	7.3	13.0	15.3	11.0	16.0	19.3
1.0	7.0	11.0	14.7	9.0	9.7	10.4
1.5	7.3	12.0	13.3	14.3	13.0	13.3
2.0	6.3	10.7	14.0	12.3	11.7	12.0
2.5	7.7	13.0	12.0	14.7	12.3	11.0
SE	1.49	2.51	2.80	6.59	6.51	9.25

Means in each column are not significantly different at $p \leq 0.05$
SE = Standard error of mean

(d) Number of Laterals

The effects of OF application rates were not significantly different on number of laterals of YPF seedlings except at 15 WAT. The control, 0.5 and 1.5 t/ha treatments had higher numbers. Those seedlings treated with OF at 1.0 and 2.0 t/ha produced lowest mean number of laterals (Table 4.9).

(e) Number of tendrils

The effects of the treatments on the number of tendrils of YPF were significantly different. The control treatment produced the highest number of tendrils whereas the seedlings treated with OF at 1.0 to 2.0 t/ha had lower but similar values (Table 4.10).

(f) Leaf area

The effects of OF rates on leaf area (LA) were not significantly different. However, highest LA was recorded in YPF seedlings treated with 2.5 t/ha. This was followed by those treated with 2.0 t/ha and control seedlings (Table 4.11).

4.4 Effects of Organic Fertiliser Application on Dry matter Production of Yellow Passion Fruit Seedlings in first Pot Experiment at Abeokuta in 2009

Application of Organic Fertiliser at 0.5 and 2.5 t/ha resulted in highest leaf dry weight which were similar to control and OF applied at 1.5 t/ha. Application of Organic Fertiliser at 1.0 and 2.0 t/ha produced lower leaf dry weight. The maximum values for YPF vine and tendrils dry weights did not follow consistent trend. Yellow Passion Fruit seedlings treated with OF at 1.5 and 2.5 t/ha produced highest vine and tendrils dry weight and were similar to values for the control, OF at 0.5 and 2.0 t/ha. The YPF seedlings applied with OF at 2.0 t/ha had the highest root dry weight and was significantly different compared to control and other OF rates. Application of OF at 2.5 t/ha resulted in lowest YPF seedling root dry weight while other OF rates had similar values. The highest total dry matter was obtained in YPF seedlings applied with OF at 1.5 t/ha. The control, OF application at 2.0, 2.5 and 0.5 t/ha had lower values. Application of at 1.0 t/ha gave the least value (Table 4.12).

Table 4.9: Effects of applied Organic Fertiliser on number of laterals of seedlings of Yellow Passion Fruit in the first pot experiment at Abeokuta in 2009

	Weeks after transplanting					
Organic Fertiliser. (t/ha)	1	3	6	9	12	15
0	0.7	0.7	0.9	1.2	1.3	2.9[a]
0.5	0.7	0.7	0.7	1.0	1.2	2.4[ab]
1.0	0.7	0.7	0.7	0.7	0.9	1.0[c]
1.5	0.7	1.0	1.2	1.2	1.5	1.8[ab]
2.0	0.7	0.7	0.7	0.7	0.7	0.7[c]
2.5	0.7	1.0	1.2	1.2	1.2	1.3[bc]
SE	0	0.28	0.34	0.49	0.59	0.64

Means in columns without letters are not significantly different at $p \leq 0.05$)
SE = Standard error of mean

Table 4.10: Effects of Organic Fertiliser application on number of tendrils of seedlings of Yellow Passion Fruit the first pot experiment at Abeokuta in 2009

	Weeks after transplanting					
Organic Fertiliser (t/ha)	1	3	6	9	12	15
0	1.0	1.8	12.3[a]	14.0	15.0	22.0
0.5	0.7	2.3	4.7[b]	10.7	14.0	16.7
1.0	1.0	1.3	2.3[b]	5.7	7.0	10.0
1.5	1.0	2.0	5.7[b]	6.3	7.0	7.7
2.0	0.7	2.0	6.0[b]	8.0	10.0	7.0
2.5	0.7	1.9	5.0[b]	7.7	10.3	10.3
SE	0.18	0.60	2.66	4.17	5.02	10.21

Means in a column without letters are not significantly different at $p \leq 0.05$)
SE = Standard error of mean

Table 4.11: Effects Organic Fertiliser application on leaf area (LA) cm^2 of seedlings Yellow Passion Fruit in the first pot experiment at Abeokuta in 2009

	Weeks after transplanting					
Organic Fertiliser (t/ha)	1	3	6	9	12	15
0	65.0	103.8	191.0	264.0	428.0	522.0
0.5	91.6	129.5	178.0	298.0	402.0	497.0
1.0	74.4	160.6	298.0	376.0	424.0	497.0
1.5	69.2	114.0	229.0	309.0	367.0	440.0
2.0	93.4	186.0	221.0	343.0	402.0	531.0
2.5	114.0	146.8	247.0	367.0	474.0	543.0
SE	23.9	38.7	76.5	98.0	122.0	104.3

Means in the columns are not significantly different at $p \leq 0.05$)
SE = Standard error of mean

Table 4.12: Effects of Organic Fertiliser application on dry matter yield of seedlings of Yellow Passion Fruit the in first pot experiment at 15 weeks after transplanting at Abeokuta in 2009

	Dry matter production (g/plant)			
Organic Fertiliser (t/ha)	Leaf dry weight	Vine +Tendrils dry weight	Root dry weight	Total dry weight
0	6.0^{ab}	26.0^{ab}	4.0^{bc}	36.0^{a}
0.5	7.0^{a}	23.0^{bc}	4.0^{bc}	34.0^{ab}
1.0	5.0^{b}	20.0^{c}	6.0^{ab}	31.0^{b}
1.5	6.0^{ab}	27.0^{a}	4.0^{bc}	37.0^{a}
2.0	5.0^{b}	23.0^{bc}	8.0^{a}	36.0^{a}
2.5	7.0^{a}	27.0^{a}	2.0^{c}	36.0^{a}
SE	0.41	1.26	0.94	1.02

Means in a column with the same letters are not significantly different ($p \leq 0.05$)
SE = Standard error of mean

4.5 Effects of Organic Fertiliser Application on Yellow Passion Fruit Seedling Foliar Nutrient Concentrations in First Pot Experiment at Abeokuta in 2009

Nitrogen

The effects of OF applied at different rates on foliar N concentration were significantly different ($p \leq 0.05$). Yellow Passion Fruit seedlings treated with OF at 2.0 and 2.5 t/ha had the highest concentrations. This was followed by seedlings that received 1.0 t/ha. Other OF rates and control recorded lower values (Table 4.13).

Phosphorus

Yellow Passion Fruit seedlings treated with OF at 1.0 t/ha had highest foliar P. This was comparable to OF at 0.5 t/ha and 2.5 t/ha The YPF seedlings treated with OF at 1.5 t/ha and those without OF application had least values (Table 4.13).

Potassium

Application of OF at 2.0 t/ha to YPF seedlings gave the highest foliar K concentration. The seedlings that did not receive OF had lower K foliar concentration. The YPF seedlings treated with other OF rates had lowest comparable values (Table 4.13).

Calcium

Yellow Passion Fruit without addition of OF had significantly highest foliar Ca concentration, followed by seedlings that received 2.0 t/ha OF. Other OF rates recorded significantly lower values (Table 4.13).

Magnesium

Yellow Passion Fruit seedlings that received 0.5 t/ha OF had the highest foliar Mg concentration. This was followed by the control treatment while seedlings treated with other OF rates recorded lowest but comparable values (Table 4.13).

Table 4.13: Foliar macronutrient concentrations (%) of Yellow Passion Fruit seedling as affected by Organic Fertiliser application 16 weeks after transplanting in first pot experiment at Abeokuta in 2009

Organic Fertiliser (t/ha)	N	P	K	Ca	Mg
0	0.14^{bc}	4.40^{bc}	1.63^{ab}	1.42^{a}	2.30^{ab}
0.5	0.10^{cd}	7.30^{ab}	0.24^{c}	0.39^{b}	2.94^{a}
1.0	0.19^{ab}	8.04^{a}	0.13^{c}	0.16^{b}	1.91^{bc}
1.5	0.07^{d}	4.50^{b}	0.72^{bc}	0.19^{b}	1.58^{c}
2.0	0.25^{a}	4.00^{b}	2.02^{a}	1.3^{a}	2.17^{bc}
2.5	0.23^{a}	7.60^{ab}	0.15^{c}	0.55^{b}	$1,71^{bc}$
SE	0.03	0.880	0.38	0.25	0.23

Means in a column with the same letters are not significantly different at ($p \leq 0.05$)
SE = Standard error of mean

Iron

Application of OF at 2.5 t/ha resulted in significantly highest foliar Fe concentrations and was not significantly different from value obtained in YPF seedlings treated 1.5 t/ha. Seedlings treated with other OF rates had similar values that were not significantly different from one another (Table 4.14).

Manganese

Yellow Passion Fruit seedlings without OF and those treated with OF at 2.0 t/ha had same maximum values. These were followed by other OF rates and lowest foliar Mn concentration was obtained in YPF seedlings that received 1.5 t/ha OF (Table 4.14).

Copper

Application of OF at 0.5 t/ha resulted in significantly highest foliar Cu concentration compared to other rates of OF. The control seedlings and seedlings that received 1.0, 1.5 and 2.0 and 2.5 t/ha of OF had similar foliar Cu concentration (Table 4.14).

Zinc

Highest foliar concentration of Zn was obtained in the YPF seedlings that received OF at 2.5 t/ha. The other OF rates gave lower and insignificantly different lower foliar Zn concentrations (Table 4.14).

4.6 Effects of Organic Fertiliser Application on Yellow Passion Fruit Seedling Foliar Nutrient Uptakes in the First Pot Experiment at Abeokuta in 2009

(a) Foliar nutrients uptakes in Yellow Passion Fruit seedlings

Application of OF significantly influenced foliar N, P, K, Mg, Fe, Mn and Cu uptakes of Yellow Passion Fruit. Plants that were treated with 0.5 t/ha OF had maximum N uptake. This was followed by seedlings that did not receive OF and other rates of OF though insignificantly different. Increased rates of Organic Fertiliser resulted in significantly lower values of N uptake (Table 4.15).

Table 4.14: Foliar micronutrient concentrations (mg/l) of Yellow Passion Fruit seedlings as affected by Organic Fertiliser application 16 weeks after transplanting in first pot experiment at Abeokuta in 2009

Organic Fertiliser (t/ha)	Fe	Mn	Cu	Zn
0	275.0^{b}	65.3^{a}	8.3^{b}	34.5^{bc}
0.5	232.5^{b}	42.5^{bc}	15.5^{a}	39.0^{bc}
1.0	360.0^{b}	35.0^{bc}	8.8^{b}	60.7^{ab}
1.5	545.0^{a}	32.5^{c}	8.5^{b}	31.8^{c}
2.0	237.5^{b}	65.0^{a}	10.3^{b}	41.25^{bc}
2.5	595.0^{a}	52.5^{ab}	10.3^{b}	63.8^{a}
SE	79.6	7.19	1.75	12.04

Means in a column with the same letters are not significantly different ($p \leq 0.05$)
SE = Standard error of mean

Table 4.15: Foliar nutrient uptake (g/plant) of Yellow Passion Fruit seedling as influenced by the Organic Fertiliser application 16 weeks after transplanting in first pot experiment at Abeokuta in 2009

Organic Fertiliser (t/ha)	N	P	K	Ca	Mg	Zn	Fe	Mn	Cu
0	0.016^{ab}	$0.001^{a\text{-}c}$	0.031^{ab}	0.011	0.009^{a}	0.265	1.93^{bc}	0.455^{a}	8.25^{b}
0.5	0.024^{a}	$0.001^{a\text{-}c}$	0.060^{a}	0.002	0.009^{a}	0.349	1.90^{bc}	0.347^{ab}	15.5^{a}
1.0	0.011^{b}	$0.001^{a\text{-}c}$	0.050^{ab}	0.00	0.00^{c}	0.388	2.10^{ab}	0.204^{bc}	8.50^{b}
1.5	0.011^{b}	0.00^{c}	0.031^{b}	0.005	0.001^{c}	0.244	3.82^{ab}	0.228^{ab}	8.75^{ab}
2.0	0.012^{b}	$0.001^{a\text{-}c}$	0.023^{b}	0.012	0.008^{ab}	0.264	1.39^{c}	0.379^{a}	10.25^{ab}
2.5	0.013^{b}	0.002^{a}	0.062^{a}	0.001	$0.004^{a\text{-}c}$	0.570	4.86^{a}	0.429^{a}	10.25^{ab}
SE	0.004	0.000	0.014	0.004	0.003	0.145	1.177	0.089	1.753

Means in a column with the same letters are not significantly ($p \leq 0.05$)
SE = Standard error of mean

The P uptake was highest in seedlings treated with OF at 2.0 t/ha. Other rates had similar values except OF supplied at 1.5 t/ha without P uptake. Application of the OF at 0.5 and 2.5 t/ha resulted in significantly highest foliar K uptake while other rates had similar lower values. Foliar Calcium and Zn uptakes of YPF seedlings were not significantly influenced by the OF rates. Yellow Passion Fruit seedlings without OF and those treated with 0.5 t/ha had significantly highest value compared to other OF rates (Table 4.15).

The foliar Fe uptake of YPF was highest in seedlings that received OF at 2.5 t/ha. Yellow Passion Fruit seedlings without OF, those applied with OF at 2.0 and 2.5 t/ha had significantly higher foliar Mn uptakes. Highest foliar Cu uptake was observed in seedlings that received 0.5 t/ha OF, followed by seedlings that received OF at 2.0 and 2.5 t/ha (Table 4.15).

(b) Total Nutrient Uptake by Yellow Passion Fruit Seedlings in the First Pot Experiment at Abeokuta in 2009

Yellow Passion Fruit seedlings treated with 0.5 t/ha OF had significantly highest N

uptake which was comparable to other rates. Other OF rates resulted in significantly lower values (Table 4.16). Phosphorus uptake was highest in seedlings treated with OF at 2.0 and 2.5 t/ha. The least total uptake of P occurred in seedlings treated with OF at 1.5 t/ha OF (Table 4.16). Potassium uptake was highest in plants that received 2.5 t/ha OF and was not significantly different from value obtained in plants that received 1.0 t/ha Organic Fertiliser This was followed by seedlings treated with OF at 0.5 t/ha, 1.5 t/ha and control. The seedlings that received OF at 2.0 t/ha had least K total uptake. Calcium uptake was highest in plants that were treated with 2.0 t/ha OF. Plants that received 0.5, 1.0 or 2.5 t/ha OF had significantly lower values compared to control and 2.0 t/ha of OF. Total Mg uptake was highest in control and OF at 2.0 t/ha. The effects of OF supplied at 0.5, 1.0 or 1.5 t/ha on Mg total uptake did not differ significantly from one another though with lower values. The Zinc uptakes were insignificantly affected by treatments though the highest uptake was obtained with Organic Fertiliser applied at 2.5 t/ha (Table 4.16).

Table 4.16: Total nutrient uptake in Yellow Passion Fruit seedling as influenced by applied first pot experiment at Abeokuta in

Organic Fertiliser (t/ha)	N	P	K	Ca	Mg	Zn	Fe	Mn	Cu
0	0.097^{ab}	0.006^{ab}	0.185^{ab}	0.069^{a}	0.059^{a}	1.59	11.5^{c}	2.73^{a}	0.346
0.5	0.117^{a}	0.004^{ab}	0.290^{ab}	0.010^{b}	0.016^{b}	1.69	9.2^{c}	1.69^{b}	0.615
1.0	0.069^{b}	0.007^{ab}	0.304^{a}	0.005^{b}	0.006^{b}	2.41	13.0^{bc}	1.27^{b}	0.316
1.5	0.068^{b}	0.003^{b}	0.194^{c}	0.031^{ab}	0.008^{b}	1.51	23.5^{ab}	1.40^{b}	0.317
2.0	0.091^{ab}	0.011^{a}	0.168^{c}	0.085^{a}	0.054^{a}	1.90	10.0^{c}	2.73^{a}	0.411
2.5	0.073^{b}	0.010^{a}	0.324^{a}	0.006^{b}	0.023^{ab}	2.97	25.3^{a}	2.24^{ab}	0.411
SE	0.016	0.026	0.059	0.030	0.020	0.676	6.16	0.563	0.118

Means in a column with the same letters are not significantly different ($p \leq 0.05$)
SE = Standard error of mean

This was followed by OF application at 1.0 t/ha while other rates had lowest values. Iron uptake was highest in plants that received 2.5 t/ha OF. This was followed by 1.5 t/ha OF rate and significantly higher than uptakes by plants that received no OF, 0.5, 1.0 and 2.0 t/ha OF. Manganese uptakes for plants that received 2.0 t/ha OF and control were the highest. Other treatments had similar values and were not significantly different except 1.5 t/ha OF rate. Copper total uptakes were not significantly influenced by OF application (Table 4.16).

4.7 Correlation of Total Nutrient Uptakes with Total Dry Weight of Yellow Passion Fruit Seedlings in First Pot Experiment at Abeokuta in 2009

Copper and Iron total uptakes showed low positive and insignificant correlation with Ca total uptake, but moderate positive and significant correlation with Cu total uptake. Potassium total uptake showed very low positive and insignificant correlation with Ca total uptake. Copper total uptake was highly positive and significantly correlated with Cu and moderately positive for Fe. Magnesium total uptake showed highly positive and significant correlation with only Ca. Manganese showed high positive and significant correlation with Ca, Cu, K, Mg and moderate with Fe (Table 4.17).

Nitrogen total uptake showed high positive and significant correlation with Cu, K and Mn but moderate positive and significant with and Mg, but moderate positive and insignificant with Ca.

Phosphorus total uptake showed similar trend as N total uptake. It showed high positive and significant correlation with K and P but moderate positive and significant correlation with Fe and moderate positive and insignificant correlation with Ca and Mg.

Zinc total uptake had low positive and insignificant correlation with Ca and Mg but high positive and significant correlation with total uptakes of Cu, Fe, K, Mn, N and P. Total dry shoot weight (TDW) showed high positive and significant correlation with Cu, Fe, K, Mn, N, P and Zn. The TDW showed moderate positive and significant correlation with Ca and insignificant with Mg total uptake (Table 4.17).

Table 4.17: Correlation coefficients between total nutrient uptake and total dry shoot weight of Yellow Passion Fruit seedlings 16 weeks after transplanting in first pot experiment at Abeokuta in 2009

Total Uptake	Ca	Cu	Fe	K	Mg	Mn	N	P	Zn
Ca									
Cu	0.35 ns								
Fe	0.49 ns	0.64**							
K	0.25 ns	0.90**	0.68**						
Mg	0.93**	0.39 ns	0.25 ns	0.29 ns					
Mn	0.84**	0.77**	0.63**	0.71**	0.86**				
N	0.54 ns	0.97**	0.62**	0.89**	0.60**	0.90**			
P	0.50 ns	0.69**	0.60**	0.88**	0.56 ns	0.82**	0.79**		
Zn	0.38 ns	0.80**	0.74**	0.95**	0.38 ns	0.76**	0.84**	0.92**	
TDW	0.63**	0.87**	0.87**	0.86**	0.55 ns	0.89**	0.91**	0.81**	0.85**

TDW = Total dry weight, ** Significant at $p \leq 0.05$ ns = Not Significant at $p \leq 0.05$

4.8: Regression Models Formulae for Predicting Relationship between Vegetative Parameters of Yellow Passion Fruit Seedlings and Organic Fertiliser Rates in First Pot Experiment at Abeokuta in 2009

There were significant positive functional relationships with rates of Organic Fertiliser for all growth parameter with the exception of number of laterals. The functional relationship was linear for YPF vine length, number of laterals, number of leaves and number of tendrils but quadratic for vine diameter. The degree of relationships for vine length, number of laterals, number of leaves and number of tendrils were 90%, 50%, 80% and 28%, for vine diameter (Table 4.18).

4.9 Regression Models for Total Dry Weight (TDW) and Total Nutrient Uptakes in First Pot Experiment at Abeokuta in 2009

Yellow Passion Fruit seedlings treated with OF showed positive significant data adjustments to linear regression models as functions of OF rates with the total uptakes of N, Mn and Fe. These were characterised by total dry weights (TDW) increase up to 65g/plant for total N uptake with OF added at 2.0 t/ha, 63 g/plant for total Mn uptake with Organic Fertiliser rate of 2.5 t/ha and 68 g/plant for total Fe uptake at OF rate of 2.5 g/ha (Figures 4.1, 4.2 and 4.4).

The TDW showed a quadratic function in relation to Cu and K total uptakes. The maximum TDW of about 55 g/plant was obtained for total Cu uptake at above 2.0 t/ha Organic Fertiliser application rate beyond which there was decrease in TDW. For total K uptake, the TDW of about 56 g/plant was obtained at OF rate of 2.0 t/ha beyond which there was decrease in total K uptake (Figures 4.3 and 4.5).

4.10 Effects of Organic Fertiliser Application on Vegetative Growth of Yellow Passion Fruit Seedlings in Second Pot Experiment at Abeokuta in 2010

(a) Vine length

The effect of OF application on vine length of YPF seedlings was significant only at 8 weeks after transplanting (WAT). Seedlings treated with OF at 2.4 t/ha had the significantly longest vine length (211.7 cm). Other treatments had similar values which were significantly longer than the seedlings treated with 0.3 t/ha OF which produced shortest vine length of 115.7 cm. At 16 WAT the longest seedling vine length (243.2 cm) occurred in seedlings treated with OF at 1.2t/ha though not significantly different from other treatments (Table 4.19).

Table 4.18: Regression models for predicting relationship between vegetative growth parameters of Yellow Passion Fruit seedlings and the rates of Organic Fertiliser at 16 weeks after transplanting in the first pot experiment at Abeokuta in 2009

Growth parameters	Regression model	Regression type	R^2 (%)	p value ($p \leq 0.05$)
Vine length (cm)	y = -54.7 – 2.47 x	Linear	90	0.015
Vine diameter (mm)	y = -8.20- 3.03 x^2	Quadratic	28	0.003
Number of laterals	y = -3.68-0.65 x	Linear	50	0.518 ns
Number of leaves	y = -1.556-2.14 x	Linear	52	0.023
Number of tendrils	y =-7.76 2.90 x	Linear	80	0.005

y = Dependent variable (Vegetative parameters)
x = Independent variable (Organic Fertiliser rates)
ns = Not significant at ($p \leq 0.05$)

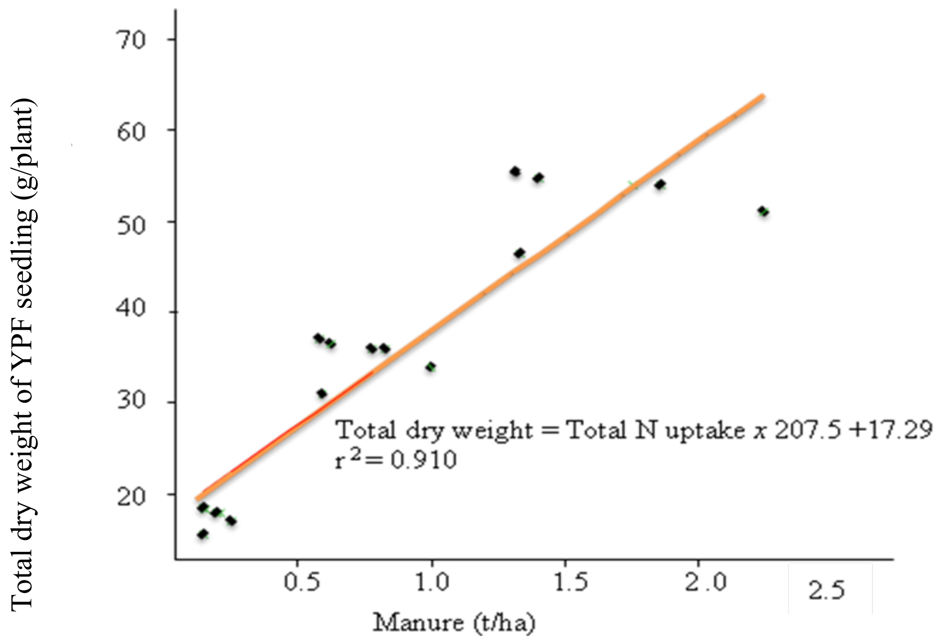

Figure 4.1: Total dry weight and total N uptake in YPF
seedlings as influenced by the Organic Fertiliser rates at Abeokuta in 2009

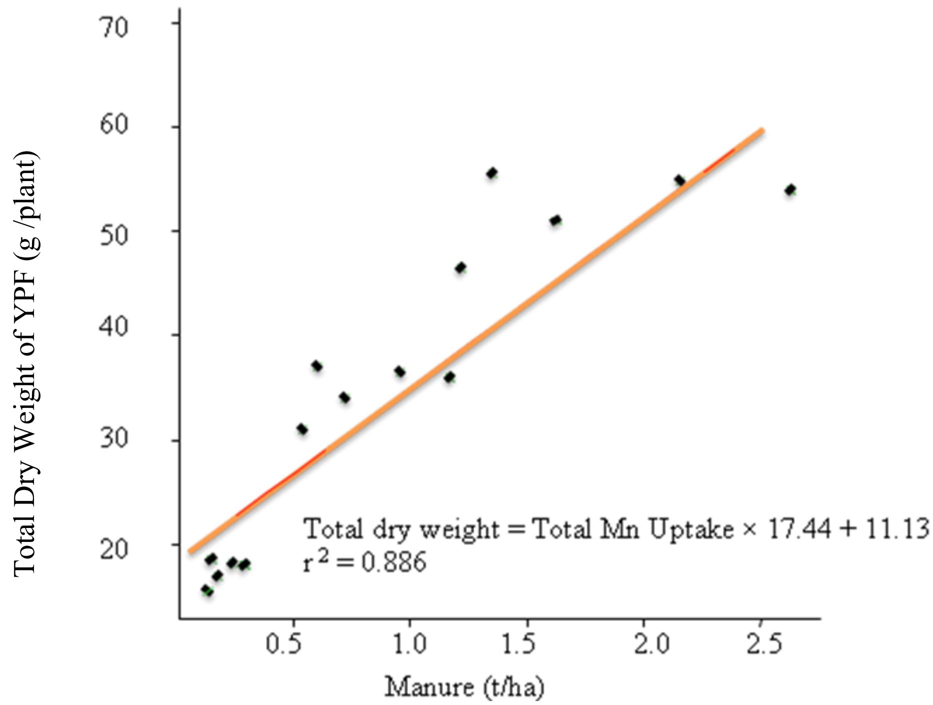

Figure 4.2: Total dry weight and total Mn uptake in Yellow Passion fruit seedlings as influenced by the Organic Fertiliser rates

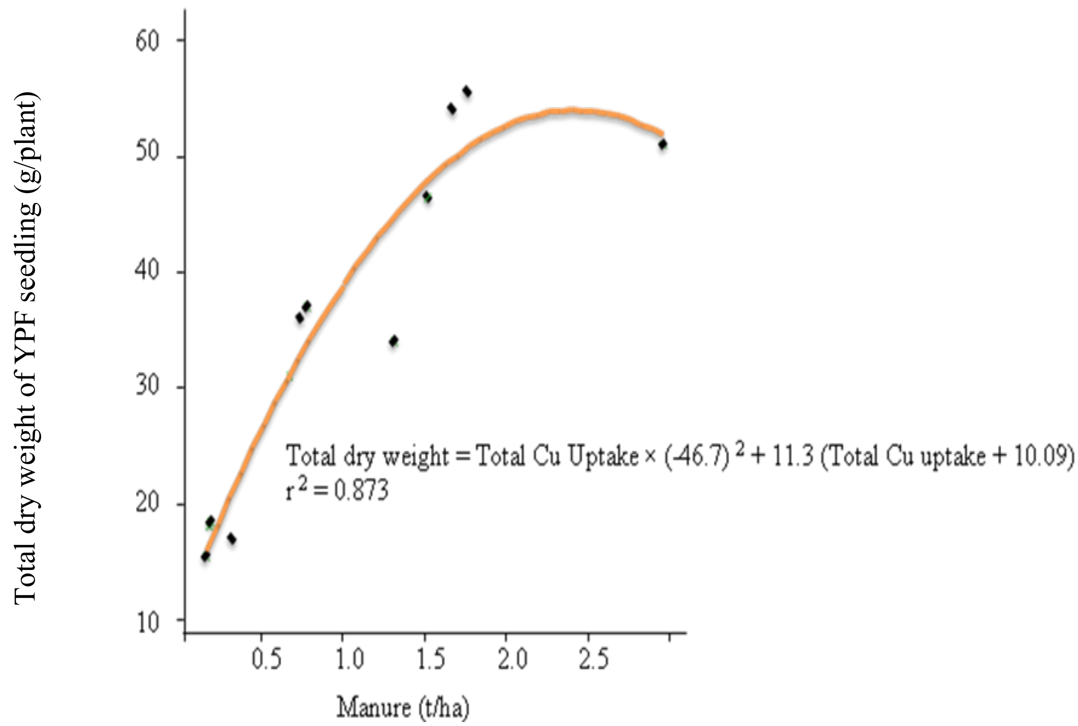

Figure 4.3: Total dry weight and total Cu uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates

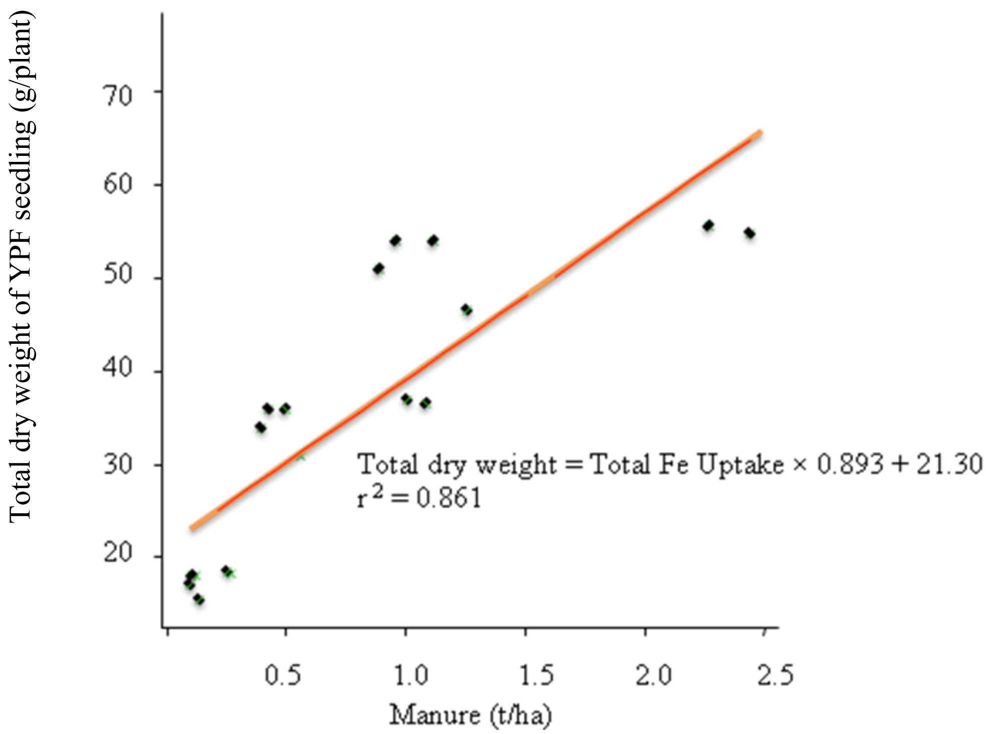

Figure 4.4: Total dry weight and total Fe uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates

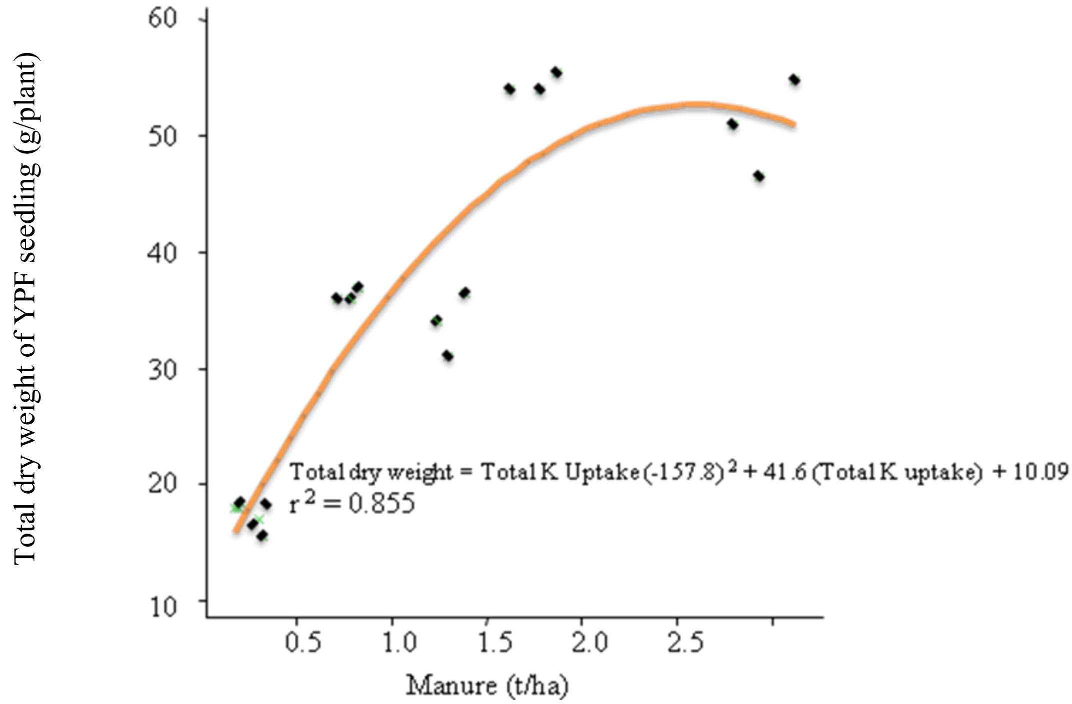

Figure 4.5: Total dry weight and total K uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates

Table 4.19: Effects of Organic Fertiliser application on vine length (cm) of seedlings of Yellow Passion Fruit in the second pot experiment at Abeokuta in 2010

Organic Fertiliser (t/ha)	Weeks after transplanting				
	1	4	8	12	16
0	12.7^{ab}	20.7	156^{ab}	189.7	202.2
0.3	11.3^{ab}	19.0	115.7^{b}	177.0	198.3
0.6	11.3^{ab}	17.7	145.0^{ab}	167.3	187.1
0.9	12.2^{ab}	17.0	144.0^{ab}	168.3	188.2
1.2	14.3^{a}	21.0	192.0^{ab}	221.3	243.2
1.5	13.3^{ab}	29.0	172.0^{ab}	191.7	212.3
1.8	13.3^{ab}	22.0	152.0^{ab}	176.7	197.3
2.1	10.7^{b}	18.0	142.7^{ab}	178.0	200.1
2.4	11.0^{b}	43.7	211.7^{a}	212.0	233.2
2.7	12.0^{ab}	27.7	155.7^{ab}	174.7	195.3
3.0	13.3^{ab}	25.0	167.3^{ab}	204.7	225.2
N.P.K 15-15-15 (50 kg/ha)	12.6^{ab}	17.7	148.7^{ab}	168.0	186.3
SE	1.21	10.50	32.00	33.90	43.50

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

(b) Vine diameter

Organic Fertiliser applied at 2.4 and 2.7 t/ha produced significantly thicker vines diameter in YPF seedlings (Table 4.20). At 4 WAT other OF rates and the control produced similar vine diameter. At 8 WAT the control treatment seedlings and those treated with OF at 2.1 and 2.4 t/ha had thickest vine diameter. At 12 WAT OF at 2.7 t/ha produced thickest vine diameter which was significantly different ($p \leq 0.05$) compared to other treatments. Organic Fertiliser at 0.6 t/ha produced lower vine diameter and lowest vine diameter in seedlings treated with OF at 0.9 t/ha (Table 4.20).

(c) Number of laterals

At 4 WAT OF applied at 1.2 t/ha produced significantly highest mean number of laterals, followed by OF at 0.9 t/ha while other rates had lowest but similar values. At 12 WAT application of the OF at 2.4 t/ha resulted in highest number of laterals while all the other treatments produced lower number of laterals per plant (Table 4.21).

(d) Number of leaves

The number of leaves of YPF seedlings increased with the age of the plants irrespective of the rates of OF from one WAT to 16 WAT. At 4 WAT seedlings treated with OF at 2.4 t/ha had the highest mean number of leaves but was not statistically different from those of seedlings that received 2.1 and 1.2 t/ha (Table 4.22). The seedlings without OF and other OF rates had statistically similar number of leaves compared to those seedlings with OF added at 2.7 t/ha. However, at 8 WAT, application of 1.2 t/ha OF resulted in highest number of leaves though not statistically different ($p \leq 0.05$) from those of seedlings that received OF at 2.4 t/ha. Other rates had similar lower number of leaves. At 12 and 16 WAT, seedlings of YPF treated with 3.0 t/ha OF produced the highest mean number of leaves but was not significantly different from the value for the seedlings that received 1.3 t/ha OF. Other treatments produced significantly lower number of leaves (Table 4.22).

Table 4.20: Effects of Organic Fertiliser application on vine diameter (mm) of Yellow Passion Fruit seedlings in second pot experiment weeks after transplanting at Abeokuta in 2010

	Weeks after transplanting			
Organic Fertiliser (t/ha)	1	4	8	12
0	0.7	0.7[b]	1.0	1.3[b]
0.3	0.7	0.7[b]	0.7	1.7[b]
0.6	0.7	0.7[b]	0.7	0.7[b]
0.9	0.7	0.9[ab]	1.4	1.6[b]
1.2	0.7	1.0[a]	1.0	1.7[b]
1.5	0.7	0.7[b]	1.0	1.4[b]
1.8	0.7	0.7[b]	1.6	1.6[b]
2.1	0.7	0.7[b]	1.3	1.6[b]
2.4	0.7	0.7[b]	2.1	2.4[a]
2.7	0.7	0.7[b]	1.0	1.7[b]
3.0	0.7	0.7[b]	1.6	1.8[b]
N.P.K. 15- 15-15 (50 kg/ha)	0.7	0.7[b]	1.0	1.6[b]
SE	0	0.10	0.59	0.19

Means in a column with same letters are not significantly different at $p \leq 0.05$

SE = Standard error of mean

Table 4.21: Effects of application of the Organic Fertiliser on number of laterals of seedlings of Yellow Passion Fruit in the second pot experiment different weeks after transplanting at Abeokuta in 2010

	Weeks after transplanting			
Organic Fertiliser (t/ha)	1	4	8	12
0	0.7	0.7^{b}	1.0	1.3^{b}
0.3	0.7	0.7^{b}	0.7	1.7^{b}
0.6	0.7	0.7^{b}	0.7	0.7^{b}
0.9	0.7	0.9^{ab}	1.4	1.6^{b}
1.2	0.7	1.0^{a}	1.0	1.7^{b}
1.5	0.7	0.7^{b}	1.0	1.4^{b}
1.8	0.7	0.7^{b}	1.6	1.6^{b}
2.1	0.7	0.7^{b}	1.3	1.6^{b}
2.4	0.7	0.7^{b}	2.1	2.4^{a}
2.7	0.7	0.7^{b}	1.0	1.7^{b}
3.0	0.7	0.7^{b}	1.6	1.8^{b}
N.P.K. 15- 15-15 (50 kg/ha)	0.7	0.7^{b}	1.0	1.6^{b}
SE	0	0.10	0.59	0.19

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Table 4.22: Effects of Organic Fertiliser rates on number of leaves of seedlings of Yellow Passion Fruit in the second pot experiment different weeks after transplanting at Abeokuta in 2010

Organic Fertiliser (t/ha)	Weeks after transplanting				
	1	4	8	12	16
0	4.7^{ab}	7.7^{ab}	18.3^{bc}	25.0^{cde}	30.0^{b}
0.3	4.7^{ab}	5.3^{b}	14.7^{c}	21.3^{f}	26.0^{bc}
0.6	5.0^{ab}	7.0^{ab}	$17.3b^{c}$	22.7^{ef}	27.7^{bc}
0.9	4.3^{b}	7.3^{ab}	17.3^{bc}	30.0^{b}	34.0^{b}
1.2	5.0^{ab}	9.3^{a}	23.3^{a}	33.3^{a}	37.8^{ab}
1.5	5.3^{a}	7.3^{ab}	18.7^{bc}	27.3^{bcd}	33.0^{ab}
1.8	5.3a	7.3^{ab}	18.3^{bc}	19.7^{f}	24.1^{c}
2.1	5.0^{ab}	9.7^{a}	18.6^{bc}	28.0^{bc}	33.4^{ab}
2.4	5.3^{a}	10^{a}	22.0^{ab}	28.7^{b}	34.0^{b}
2.7	4.7^{ab}	8.0^{ab}	18.0^{bc}	$24,7^{dc}$	29.0^{b}
3.0	5.3^{a}	7.7^{ab}	18.7^{bc}	35.3^{a}	41.5^{a}
N.P.K. 15-15-15 (50 kg/ha)	5.3^{a}	7.3^{ab}	17.7^{bc}	24.7^{de}	28.2^{b}
SE	0.37	1.46	1.96	1.39	1.45

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

(e) Leaf area (LA)

The seedlings LA increased with age of seedlings irrespective of the OF rates, However, the effects of OF application were not significant throughout observation period. At 4, 8 and 12 WAT application of N.P.K. 15-15-15 at 50 kg/ha produced highest LA values (Table 4.25). However, at 16 WAT, seedlings that received 2.1 t/ha OF produced the largest LA, followed by 0.6 t/ha OF and 1.8 t/ha (Table 4.23).

(f) Number of tendrils

The effects of OF rates on YPF number of tendrils were significant at 8 and 16 WAT. Yellow Passion Fruit seedlings treated with OF at 2.4 t/ha had the highest number of tendrils at 8 and 16 WAT. Seedlings treated with 0.3 t/ha OF had the least number of tendrils which was similar to those produced by seedlings supplied with OF at 0.6 t/ha (Table 4.24).

Yellow Passion Fruit seedlings that received N.P.K.15-15-15 at 50kg/ha and OF at 0.9 t/ha had similar values. Other treatments had values in the range of 11.3 to 11.7 and were not significantly different. At 12 WAT, seedlings supplied with OF at 3.0 t/ha had the maximum value, followed by OF applied at 1.2, 1.5, 2.4 and 2.7 t/ha with similar lower values. However at 16 WAT application of OF at 2.4 and 3.0 t/ha had comparable maximum values which were significantly different from other rates. Applied OF at 2.1 t/ha had significantly lowest number of tendrils in the YPF seedlings (Table 4.24).

4.11 Effects of Organic Fertiliser Application on Leaf Chlorophyll Content of Yellow Passion Fruit seedlings in Second Pot Experiment at Abeokuta in 2010

The applied OF did not have significant effects on the leaf chlorophyll content of YPF seedlings 12 WAT. The chlorophyll content meter readings were highest in plants treated with Organic Fertiliser at 1.5 and lower in seedlings that received OF at 2.4 t/ha. The lowest chlorophyll content meter reading was obtained in plants treated with Organic Fertiliser at 0.6 t/ha (Table 4.25).

Table 4.23: Effects of Organic Fertiliser application on leaf area cm^2 of seedling of Yellow Passion Fruit in the second pot experiment during the first 16 weeks after transplanting at Abeokuta in 2010

	Weeks after transplanting				
Organic Fertiliser (t/ha)	1	4	8	12	16
0	64	293	485	595	695
0.3	128	256	434	526	620
0.6	73	275	419	570	730
0.9	82	174	500	595	690
1.2	155	302	537	566	590
1.5	165	356	478	588	698
1.8	82	256	415	568	721
2.1	91	265	493	650	807
2.4	137	348	496	586	676
2.7	100	242	452	586	624
3.0	73	339	518	561	604
N. P. K. 15-15-15 (50 kg/ha)	170	375	579	650	720
SE	61.6	104.3	170.0	72.0	61.0

Means in each column are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Table 4.24: Effects of the Organic Fertiliser application on number of tendrils of Yellow Passion Fruit seedlings in second pot experiment at Abeokuta in 2010

	Weeks after transplanting				
Organic Fertiliser (t/ha)	1	4	8	12	16
0	0.7	0.9	10.0^{bc}	19.3^{bc}	28.3^{abc}
0.3	0.7	0.9	7.7^{c}	15.7^{c}	24.0^{bc}
0.6	0.7	0.7	9.0^{c}	14.7^{c}	20.0^{bc}
0.9	0.7	0.7	9.7^{bc}	17.3c	26.5^{bc}
1.2	0.7	0.7	11.3^{abc}	21.0^{abc}	30.1^{ab}
1.5	0.7	1.3	13.0^{ab}	23.3^{abc}	33.2^{ab}
1.8	0.7	0.9	10.7^{ab}	18.3^{bc}	25.0^{bc}
2.1	0.7	0.7	13.4^{ab}	16.0^{c}	18.0^{c}
2.4	0.7	1.4	16.0^{a}	28.7^{ab}	38.0^{a}
2.7	0.7	1.0	11.7^{abc}	21.3^{abc}	30.7^{ab}
3.0	0.7	1.0	11.7^{abc}	30.3^{a}	37.0^{a}
N. P. K. 15-15-15 (50 kg/ha)	0.7	0.7	9.0^{bc}	9.0b^{c}	24.5^{bc}
SE	0	0.37	2.53	3.7	52.90

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

4.12 Effects of Organic Fertiliser application on Dry Weight (g) of Yellow Passion Fruit seedlings at 16 Weeks After Transplanting in Second Pot Experiment at Abeokuta in 2010

Application of the OF at the different rates had significant effects on the biomass of YPF seedlings 16 WAT. Organic Fertiliser applied at 2.4 t/ha resulted in highest leaf dry weight, vine and tendrils dry weight and total dry weight. Application of OF at 1.2 and 1.8 t/ha however resulted in similar and highest root dry weights. These were closely followed by N. P. K. 15-15-15 at 50 kg/ha application. Conversely, application of OF at 0.6 t/ha, 1.2 t/ha and 2.7 t/ha resulted in consistently lowest YPF leaf, vine and tendrils dry weights (Table 4.25).

4.13 Effects of Organic Fertiliser on Foliar Nutrient Uptake (g/plant) of Yellow Passion Fruit Seedlings in Second Pot Experiment at Abeokuta In 2010

Application of 2.4 t/ha OF led to the highest foliar uptakes N, P, K, Ca, Mg, Zn, Fe and Mn in YPF seedlings. This was followed by application of 0.3 t/ha OF which resulted in higher values for foliar uptake of these nutrients and Cu. The effects of other application rates on foliar nutrients uptake were not consistent (Table 4.26).

4.14 Correlation of Nutrient Uptakes with Total Dry Weight of Yellow Passion Fruit Seedlings in Second Pot Experiment at Abeokuta in 2010

Magnesium total uptakes showed low positive and highly significant correlation ($p \leq 0.05$) with total K uptake. Nitrogen total uptake showed positive and highly significant correlation with K and Mg total uptakes. Similar trends were observed for total uptakes of P and Ca with K, Mg, N and P.

Copper total uptake showed low positive and significant correlation ($p \leq 0.01$) with Mg, N, P, Ca with exception of K total uptake which was insignificant.

Iron, Mg and Zn total uptakes were positive and highly significantly correlated ($p \leq 0.05$) with K, Mg, N, P and Ca but insignificant with Cu. The total dry shoot weight (TDW) showed positive and highly significant correlation with all other nutrient uptakes except Cu which was not significant (Table 4.27).

Table 4.25: Effects of Organic Fertiliser rates on foliar chlorophyll content and dry weight (g)/plant) of Yellow Passion Fruit seedlings in second pot experiment 16 weeks after transplanting at Abeokuta in 2010

Organic Fertiliser (t/ha)	Foliar Chlorophyll content /plant	Dry weight			
		Leaves**	Vines + Tendrils**	Root	Total **
0	32.1	11.0^{cd}	51.0^{bc}	9.0^{f}	71.0^{bcd}
0.3	33.9	14.0^{bc}	46.0^{d}	9.0^{f}	69.0^{bcd}
0.6	28.1	9.0^{d}	40.0^{f}	12.0^{cd}	61.0^{d}
0.9	34.5	12.0^{bcd}	53.0^{b}	8.0^{g}	73.0^{bc}
1.2	30.6	9.0^{d}	46.0^{d}	15.0^{a}	70.0^{bcd}
1.5	35.6	13.0^{bc}	47.0^{d}	11.0^{cde}	71.0^{bcd}
1.8	31.8	10.0^{cd}	43.0^{e}	14.0^{ab}	67.0^{cd}
2.1	33.5	13.0^{bc}	50.0^{c}	10.0^{def}	73.0^{bc}
2.4	35.6	21.0^{a}	63.0^{a}	12.0^{cd}	96.0^{a}
2.7	34.4	11.0^{cd}	40.0^{f}	13.0^{c}	64.0^{cd}
3.0	34.4	12.0^{bcd}	50.0^{c}	9.0^{f}	71.0^{bcd}
N. P. K. 15-15-15(50 g/ha)	35.4	15.0^{b}	53.0^{b}	12.0^{bcd}	80.0^{b}
SE	3.85	0.38	0.96	0.45	3.92

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean
FC /plant = Foliar chlorophyll content/plant
* Readings were taken at 12 weeks after transplanting
** Data were taken at 16 weeks after transplanting

Table 4.26: Foliar nutrient uptake (g/plant) of Yellow Passion Fruit seedling as influenced by Organic Fertiliser application in second pot experiment at Abeokuta in 2010

Organic Fertiliser (t/ha)	**N**	P	K	Ca	Mg	Zn	Fe	Mn	Cu
0	0.0205^{b}	0.001^{bc}	0.024^{b}	0.022^{bcd}	0.011^{bc}	0.558^{bcd}	3.85^{b}	0.968^{bc}	0.058^{b}
0.3	0.020^{b}	0.001^{bc}	0.022^{b}	0.029^{ab}	0.013^{abc}	0.652^{bc}	4.85^{b}	0.910^{bc}	0.148^{b}
0.6	0.016b^{c}	0.002^{ab}	0.021^{b}	0.024^{bcd}	0.014^{ab}	0.554^{bcd}	5.25^{b}	1.417^{ab}	0.024^{b}
0.9	0.020b^{c}	0.002^{ab}	0.019^{b}	0.026^{a-d}	0.011^{bc}	0.406^{bcd}	4.20^{b}	0.875^{bc}	0.200^{b}
1.2	0.016b^{c}	0.002^{ab}	0.020b	0.012^{e}	0.007^{c}	0.347^{d}	2.63^{b}	0.525^{c}	0.265^{b}
1.5	0.029b^{c}	0.002^{ab}	0.025^{b}	0.026^{a-d}	0.013^{abc}	0.675^{abc}	4.97^{b}	1.365^{ab}	0.288^{b}
1.8	0.026^{bc}	0.001^{bc}	0.017^{b}	0.027^{abc}	0.011^{bc}	0.467^{bcd}	3.44^{b}	1.170^{b}	0.233^{b}
2.1	0.029^{bc}	0.002$_{ab}$	0.026^{b}	0.019^{cde}	0.013^{abc}	0.667^{abc}	8.11^{b}	0.948^{bc}	0.000^{b}
2.4	0.062^{a}	0.003^{a}	0.041^{a}	0.034^{a}	0.018^{a}	1.004^{a}	17.39^{a}	1.840^{a}	0.031^{b}
2.7	0.024^{bc}	0.001^{bc}	0.025^{b}	0.017^{de}	0.012^{abc}	0.735^{ab}	3.53^{b}	1.380^{ab}	0.016^{b}
3.0	0.032^{bc}	0.001^{bc}	0.029^{b}	0.019^{cde}	0.014^{ab}	0.728ab	5.53^{b}	1.435^{ab}	0.000^{b}
N.P.K.	0.037^{bc}	0.002^{ab}	0.020^{b}	0.020^{b-e}	0.012^{abc}	0.621^{bcd}	6.39^{b}	1.312^{ab}	0.661^{a}
SE	0.010	0.0004	0.004	0.005	0.002	0.150	3.000	0.303	0.1404

Means in a column with same letters are not significantly different at $p \leq 0.05$
N.P.K. = N. P. K. 15-15-15 at 50kg/ha SE = Standard error of mean

Table 4.27: Correlation of total nutrient uptake and total dry weight of Yellow Passion Fruit seedling 16 WAT in second pot experiment at Abeokuta in 2010

TU	K	Mg	N	P	Ca	Cu	Fe	Mn	Zn
K									
Mg	0.91**								
N	0.91**	0.82**							
P	0.92**	0.94**	0.88**						
Ca	0.89**	0.97**	0.81**	0.92**					
Cu	0.39ns	0.43*	0.44*	0.60**	0.47*				
Fe	0.83**	0.85**	0.87**	0.88**	0.84**	0.32ns			
Mn	0.87**	0.98**	0.81**	0.90**	0.94**	0.39ns	0.84**		
Zn	0.93**	0.98**	0.86**	0.95**	0.94**	0.43ns	0.87**	0.97**	
TDW	0.95**	0.84**	0.95**	0.92**	0.85**	0.51ns	0.83**	0.80**	0.87**

** Highly significant at $p \leq 0.05$
* Significant at $p \leq 0.01$
TDW = Total dry weight TU = Total Uptake

4.15 Regression models for predicting relationship between vegetative parameters of Yellow Passion Fruit seedlings and Organic Fertiliser rates in second pot experiment at Abeokuta in 2010

The responses exhibited by the various YPF seedlings vegetative parameters in respect to the applied OF showed significant functional relationships except the vine diameter. The relationships were quadratic for vine length, vine diameter, number of laterals, number of leaves and number of tendrils. The degree of relationships for VL, VD, NLt, NL and number of tendrils were 84.2, 37.8, 85.2, 93.4 and 89.2% respectively (Table 4.28).

4.16 Regression models for Total dry weight (TDW) and Total Nutrient uptakes in YPF seedlings in second pot experiment at Abeokuta in 2010

Yellow Passion Fruit TDW exhibited significant functional relationship with OF application. The relationships were quadratic for TDW with N and K uptakes. The degree of relationships between TDW and uptakes of N and K indicated 95.3% and 94% while total P uptake presented a linear relationship (Figure 4.6).
Similar trends were observed for P and K uptakes which increased with increased Organic Fertiliser rates. The values of uptake for P were 140 g/plant and 120 g/plant (Figures 4.7 and 4.8).

4.17 Nutrient concentration in the leaves of Yellow Passion Fruit seedlings as influenced by Organic Fertiliser application in second pot experiment at Abeokuta in 2010

Nitrogen

Yellow Passion Fruits seedlings without OF and those treated with OF at 0.3, 0.9 and 1.2 t/ha had significantly lower leaf N concentrations compared to the maximum of those treated with OF at 1.8, 2.4 and 3.0 t/ha or N.P.K 15-15-15 at 50 kg/ha. Application of OF at 3.0 t/ha gave the highest leaf N concentration followed by 1.8 and 2.4 t/ha OF rates and N.P.K.15-15-15 at 50 kg/ha. The control and those that seedlings received OF at 0.6, 0.9 and 1.2 t/ha had lower leaf N concentrations. The least foliar N concentration was obtained from seedlings treated with Organic Fertiliser at 0.3 t/ha (Table 4.29).

Table 4.28: Regression models for predicting relationship between vegetative growth parameters of seedlings of Yellow Passion Fruit and the Organic Fertiliser rates at 16 weeks after transplanting in second experiment at Abeokuta in 2010

Growth parameters	Regression model	Regression type	R2 (%)	p value ($p \leq 0.05$)
Vine length (cm)	$y = -0.333x^2 + 0.666x$	Quadratic	84.2	0.816
Vine diameter (mm)	$y = 0.767x^2 + 0.810x$	Quadratic	37.8	0.345ns
Number of laterals	$y = 0.058x^2 + 0.113x$	Quadratic	52.0	0.611
Number of leaves	$y = 0.16x^2 + 2.03x$	Quadratic	93.4	0.936
Number of tendrils	$y = 0.1x^2 + 1.93x$	Quadratic	89.2	0.608

y = Dependent variable (Vegetative parameters)
x = Independent variable (Organic Fertiliser rates)

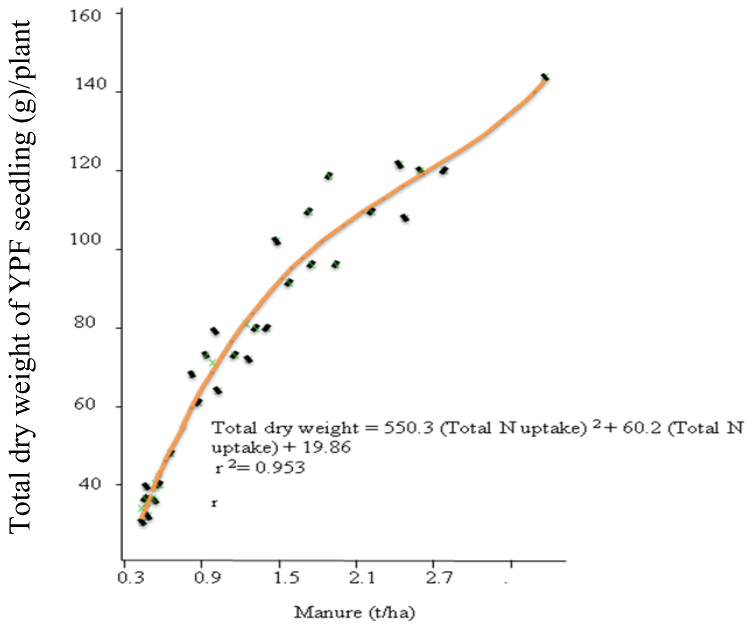

Figure 4.6: Relationship between total dry weight and total N uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates at Abeokuta in 2010

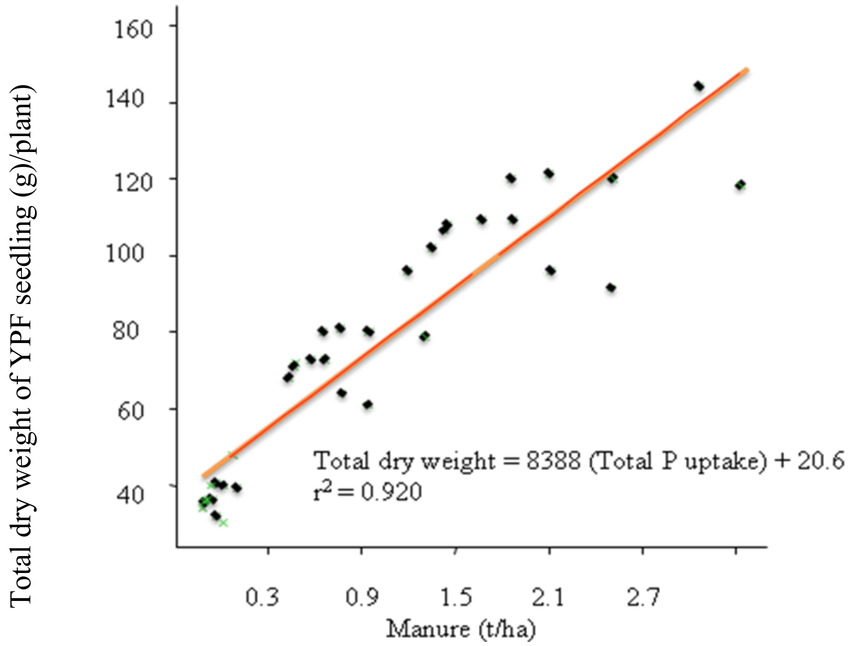

Figure 4.7: Relationship between total dry weight and total P uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates

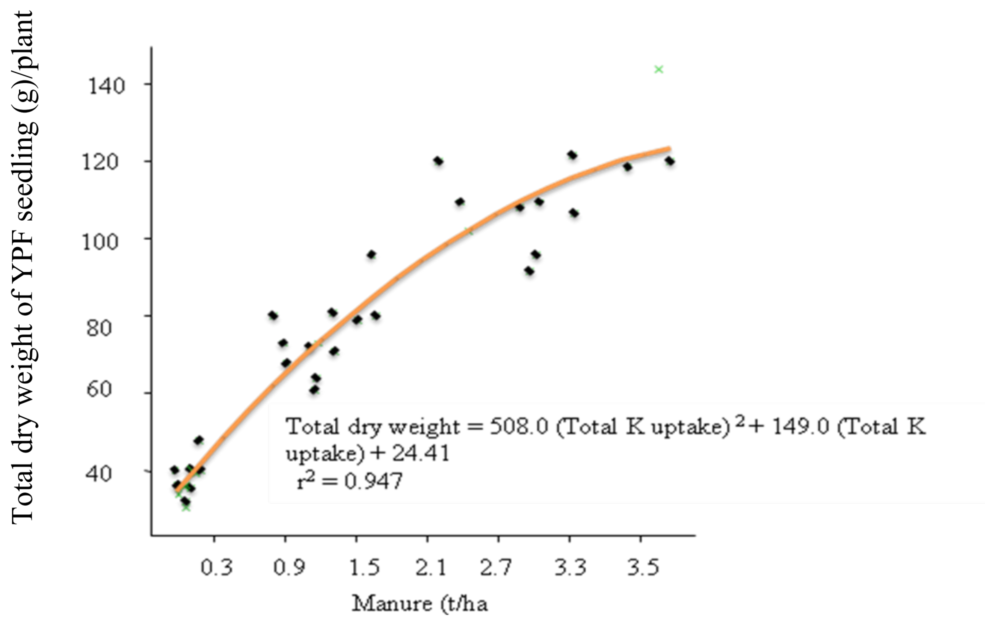

Figure 4.8: Relationship between Total dry matter and Total K uptake in Yellow Passion Fruit seedlings as influenced by the Organic Fertiliser rates at Abeokuta in 2010

Phosphorus

Organic Fertiliser application significantly influenced P concentration of YPF seedlings; OF applied at 0.6 and 1.2 t/ha gave highest foliar P concentration (Table 4.29).

Potassium

Significantly highest foliar K concentration (2.0 b%) was in seedlings treated with 3.0 t/ha OF. The control, OF at 0.6, 1.2 and 2.7 t/ha had values that were not significantly different from one another. They however had values that were significantly higher than plants that received 0.3, 0.9, 1.5, 1.8, 2.1, 2.4 t/ha OF or 50 kg N.P.K. 15 --15 -15 -15 (Table 4.29).

Calcium

Seedlings treated with OF at 0.6 t/ha had significantly highest foliar Ca concentration. Seedlings with OF applied at 1.8 t/ha had lower concentration while other OF rates recorded significantly lowest foliar Ca concentration (Table 4.29).

Magnesium

Organic Fertiliser application rate significantly influenced foliar Mg concentration. Magnesium foliar concentration was highest in plants that received 0.6 t/ha OF. Those seedlings that received 1.8 t/ha OF had lower foliar Mg concentration. Yellow Passion Fruit seedlings that received other rates of OF and control had similar but lowest foliar Mg consecrations (Table 4.29)

Zinc

Organic fertiliser at 0.6, 2.7 and 3.0 t/ha resulted in comparable maximum leaf Zn concentration of YPF seedlings; and significantly different from other OF rates which had lower values. OF at 0.9 t/ha had the lowest foliar concentration Zn which was similar to concentration obtained in seedlings treated with 1.2 t/ha OF. Application of N.P.K.15-15-15 at 50 kg/ha had the least foliar Zn (Table 4.30).

Table 4.29: Influence of Organic Fertiliser application rate on leaf macronutrient concentrations in Yellow Passion Fruit 16 weeks after transplanting in second pot experiment at Abeokuta in 2010

Organic Fertiliser (t/ha)	N	P	K	Ca	Mg
	(.%)				(g/l)
0	1.60^{bcd}	0.09^{c}	1.90^{ab}	1.76^{cde}	0.82^{bcd}
0.3	1.29^{d}	0.09^{c}	1.50^{cd}	1.95^{abc}	0.88^{bcd}
0.6	1.56^{bcd}	0.17^{a}	1.98^{ab}	2.27^{ab}	1.33^{a}
0.9	1.4^{cd}	0.11^{bc}	1.6^{cd}	1.85^{bcd}	0.80^{bcd}
1.2	1.49^{cd}	0.17^{a}	1.92^{ab}	1.18^{fg}	0.69^{cd}
1.5	1.95^{ab}	0.11^{bc}	1.66^{bc}	1.7^{cdef}	0.89^{bcd}
1.8	2.24^{a}	0.09^{c}	1.64^{bc}	2.32^{a}	1.02^{b}
2.1	1.95^{ab}	0.10^{bc}	1.70^{bc}	1.23^{fg}	0.85^{bcd}
2.4	2.24^{a}	0.13^{abc}	1.68^{bc}	1.39^{def}	0.73^{cd}
2.7	1.90^{abc}	0.14^{ab}	1.92^{ab}	1.31^{efg}	0.92^{bc}
3.0	2.30^{a}	0.10^{bc}	2.00^{a}	1.38^{defg}	1.03^{b}
N. P.K. 15-15-15 (50 kg/ha)	2.13^{a}	0.13^{abc}	1.16^{d}	1.15^{g}	0.66^{d}
SE	0.164	0.013	0.114	0.175	0.077

Means in a column with same letters are not significantly different at ($p \leq 0.05$)
SE = Standard error of mean

Table 4.30: Foliar micronutrient concentrations of Yellow Passion Fruit seedlings as affected by Organic Fertiliser application 16 weeks after transplanting in second pot experiment at Abeokuta in 2010

	Zn	Fe	Mn	Cu
Organic Fertiliser (t/ha)	---------------------------------	---------------------------------	mg/l ---------------------------	
0	43.50^{b}	300.0^{de}	75.0^{cd}	4.50^{cd}
0.3	43.00^{bc}	320.0^{de}	60.0^{de}	9.75^{bc}
0.6	52.75^{a}	500.0^{bc}	135.0^{a}	2.2^{c}
0.9	29.00^{e}	300.0^{de}	62.5^{de}	14.25^{b}
1.2	33.00^{de}	250.0^{e}	50.0^{e}	25.25^{ab}
1.5	44.50^{b}	327.5^{de}	90.0^{bc}	19.00^{abc}
1.8	40.00^{bcd}	295.0^{de}	100.0^{b}	20.00^{ab}
2.1	44.0^{b}	533.0^{b}	62.5^{de}	1.25^{d}
2.4	41.0^{bc}	710.0^{a}	75.0^{cd}	1.25^{d}
2,7	57.25^{a}	275.0^{de}	107.5^{b}	1.25^{d}
3.0	52.00^{abc}	395.0^{de}	102.5^{b}	37.75^{a}
N. P. K. 15-15-15 (50 kg/ha)	35.00^{cde}	365.0^{de}	75.0^{cd}	1.25^{d}
SE	4.123	67.8	12.31	18.301

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Iron

Organic Fertiliser applied at 2.4 t/ha gave the maximum foliar Fe concentration and was significantly higher than the maximum for other treatments. The OF applied at 0.6 and 2.1 t/ha had comparable Fe concentrations. Other rates had significantly lower values (Tables 4.30).

Manganese

Application of OF at 0.6 t/ha resulted in maximum leaf Mn concentration and was significantly different from other treatments. Organic Fertiliser applied at 2.7, 3.0 t/ha and 1.8 t/ha had comparable Mn concentration. Yellow Passion Fruit seedlings in control treatment, OF at 2.4 t/ha and N.P.K.15-15-15 at 50 kg/ha had same leaf Mn concentrations while OF at 1.2 t/ha had the significantly lowest leaf Mn concentrations (Table 4.30).

Copper

Copper concentration was significantly influenced by OF application rates. Yellow Passion Fruit seedlings treated with OF at 3.0t.ha had highest leaf Cu concentration. Seedlings with OF application at 1.2 and 1.8 t/ha had similar higher concentrations. Other application rates of OF and control resulted in comparable values (Table 4.30).

4.18 Effects of Organic Fertiliser Rates on Total Nutrient Uptake (g) of Yellow Passion Fruit Seedlings in Second Pot Experiment at Abeokuta in 2010

The total nutrient uptakes for N, P, Ca, Mg, Fe and Mn in YPF seedlings were significantly affected by OF application rates. Application of 2.4 t/ha of OF to the seedlings resulted in maximum total N, P and Fe uptakes (Table 4.31). Yellow Passion Fruit seedlings treated with OF at 0.6 t/ha recorded highest total uptakes of Ca, Mg and Mn. The total P uptakes in seedlings treated with OF at 0.6, 0.9, 1.2, 1.5 and 2.1 t/ha were similar to the highest of seedlings treated with OF at 3.0 t/ha. The total uptake of K was not significantly affected by the OF application rate, however the highest total K uptake was obtained in seedlings supplied with OF at 3.0 t/ha (Table 4.31). Organic Fertiliser applied at 1.2 t/ha resulted in the least value for total Ca uptake. Organic Fertiliser applied at rates of 2.1, 2.7 and 3.0 t/ha resulted in lowest total Ca uptake.

The uptakes of Mg in YPF seedlings treated with OF at 0.6, 2.1 and 3.0 t/ha had similar highest values. Seedlings of YPF treated with OF at 0.3, 1.5 2.1, 2.7 and 3.0 t/ha OF.

Application of OF at 0.6 t/ha resulted in highest Mn uptake which was similar to uptakes obtained with OF supplied at 1.2, 1 5, 1.8, 2.7, 3.0 and N.P.K.15-15-15 at 50 kg/ha (Table 4.31).

Highest uptake of Cu was obtained with N.P.K.15-15-15 at 50 kg/ha and was significantly higher than OF added at 2.1, 2.7 and 3.0 t/ha. The total Cu uptake in YPF seedlings was similar for 0.3, 0.6, 0.9, 1.2, 1.5, 1.8 and 2.4 t/ha OF. Application of OF had no significant effects on K and Zn total uptakes though highest K uptake was obtained with OF at 3.0 t/ha. The Zn total uptake was 0.82 g/plant from OF added at 0.6 t/ha (Table 4.31).

4.19 Effects of Organic Fertiliser Application on Vegetative Growth of Yellow Passion Fruit Seedlings in Third Pot Experiment at Abeokuta in 2016

(a) Vine length

The effects of OF application rates on seedling vine length were significant only at 8 WAT. The application of OF at 5.5 t/ha was significantly higher compared to other rates though similar to the control. The longest vine length at 16 WAT was obtained from YPF seedlings treated with OF at 11 t/ha (Table 4.32)

(b) Number of leaves

At 4 WAT, YPF seedlings without OF applied had significantly highest number of leaves compared to other rates. The effects of the applied OF on number of leaves were not significant between 6 and 10 WAT. At 12 and 14 WAT application of OF at 5.5 t/ha recorded lowest number of leaves. Organic Fertiliser applied at 16.5 t/ha had the highest number of leaves, followed by the control and OF applied at 11 t/ha with values (Table 4.33).

Table 4.31: Effect of Organic Fertiliser application rates on Yellow Passion Fruit seedlings total nutrient uptake (g/plant) in second experiment at Abeokuta in 2010

Organic Fertiliser (t/ha)	N	P	K	Ca	Mg	Zn	Fe	Mn	Cu
0	0.133^{e}	0.007^{b}	0.157	0.017^{b}	0.007^{b}	0.42	2.88^{b}	0.72^{b}	0.043b
0.3	0.102^{f}	0.007^{b}	0.119	0.018^{ab}	0.008^{b}	0.40	2.94^{b}	0.55^{b}	0.090^{ab}
0.6	0.111^{f}	0.012^{ab}	0.141	0.035^{a}	0.021^{a}	0.82	7.78^{ab}	2.10^{a}	0.035^{ab}
0.9	0.124^{ef}	0.009^{b}	0.116	0.022^{ab}	0.009^{b}	0.35	3.61^{b}	0.75^{b}	0.172^{ab}
1.2	0.137^{e}	0.016^{a}	0.179	0.024^{ab}	0.014^{ab}	0.67	5.04^{ab}	1.00^{ab}	0.509^{ab}
1.5	0.184^{cd}	0.010^{ab}	0.157	0.023^{ab}	0.011^{b}	0.60	4.38^{b}	1.20^{ab}	0.259^{ab}
1.8	0.188^{cd}	0.008^{b}	0.138	0.023^{ab}	0.010^{b}	0.39	2.87^{b}	0.97^{ab}	0.194^{ab}
2.1	0.166^{d}	0.009^{b}	0.145	0.014^{b}	0.009^{b}	0.48	5.86^{ab}	0.68^{b}	0.000^{b}
2.4	0.282^{a}	0.015^{a}	0.188	0.026^{ab}	0.014^{a}	0.77	13.30^{a}	1.40^{ab}	0.023^{b}
2.7	0.142^{e}	0.010^{ab}	0.143	0.018^{ab}	0.012^{b}	0.77	3.70^{b}	1.40^{ab}	0.017^{b}
3.0	0.214^{b}	0.009^{b}	0.192	0.017^{b}	0.012^{b}	0.62	4.74^{b}	$1.23a^{b}$	0.000^{b}
NPK	0.199^{b}	0.012^{ab}	0.108	0.018^{ab}	0.010^{b}	0.55	5.69^{ab}	1.17^{ab}	0.589^{a}
SE	0.008	0.002	0.002	0.006	0.003	0.156	2.781	0.406	0.190

Means in a column with same letters are not significantly different at $p \leq 0.05$
N.P.K. = N. P. K. 15-15-15 (50kg/ha)   SE = Standard error of mean

Table 4.32: Effects of Organic Fertiliser rates on vine length (cm) of Yellow Passion Fruit seedlings during the first 16 weeks after transplanting in third pot experiment at Abeokuta in 2016

Organic Fertiliser (t/ha)	Weeks after transplanting							
	2	4	6	8	10	12	14	16
0	8.9	10.7	11.9	9.6	12.8	21.8	32.4	52.7
5.5	9	7	9.2	8.8	14.6	15.9	23.1	44.5
11	9.5	6.8	9.8	9.6	12.1	21.3	31.7	54.3
16.5	8.8	5.8	11.8	8.2	13.0	24.6	36.9	59.6
LSD (0.05)	1.723	2.024	3.492	5.427	4.965	6.96	7.38	26.88

LSD = Least significant difference
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Table 4.33: Effects of Organic Fertiliser application rates on mean number of leaves of Yellow Passion Fruit seedlings in third pot experiment at different weeks after transplanting at Abeokuta in 2016

	Weeks after transplanting							
Organic Fertiliser (t/ ha)	2	4	6	8	10	12	14	16
0	23.25	23.62	25.81	30.44	30.3	58.8	81.1	108
5.5	23.38	22.38	24.84	31.38	34.1	39.1	55.7	104
11.0	24.19	22.94	22.88	26.46	28.9	45.2	66.1	147
16.5	26.19	21.69	23.12	26.82	29.8	44.4	64.4	108
LSD (0.05)	3.704	2.616	3.127	3.9*	7.26	20.81	34.63	67.1

LSD = Least significant difference
*Significant at $p \leq 0.05$

(c) Number of Laterals

The laterals of Yellow Passion Fruit seedlings were not significantly affected by the OF rates. Control seedlings had initial mean value of 2.7, followed by 2.5 for seedlings treated with OF at 5.5 and 11 t/ha. Yellow Passion Fruit seedlings supplied with 5.5 t/ha had the least value. Similar trend was observed at 14 WAT but at 16 WAT control had the least value. Organic Fertiliser supplied at16.5 t/ha had highest number of laterals (Table 4.34).

(d) Leaf area

The leaf area (LA) of YPF seedlings increased with the age of the seedlings irrespective of the treatments. The effects of applied OF were not significantly different between 2 and 10 WAT but became evident from 12 WAT. Organic Fertiliser applied at rate 16. 5 t/ha produced highest LA value compared to 5.5 t/ha while control and 11 t/ha were similar but lowest values (Figure 4.9).

4.20 Effect s of Organic Fertiliser Application on number of Tendrils, Foliar Chlorophyll Content and Dry Weight (g/plant) of Yellow Passion Fruit Seedlings in Third Pot Experiment at Abeokuta in 2016

(a)Number of tendrils

The formation of tendrils in YPF seedlings commenced 10 WAT and was not affected by the OF application rate (Table 4.38). Yellow Passion Fruit seedlings treated with OF at 11 t/ha had the least number of tendrils at 10 WAT followed by OF added at 5.5 t/ha while the control had the highest number. At 12 WAT application of OF at 16.5 t/ha produced highest number of tendrils which was not significantly different from other treatments (Table 4.35).

(b) Foliar chlorophyll content

The foliar chlorophyll content of YPF seedlings was affected by OF application. At 8 WAT the OF effects were not significantly different, however the chlorophyll content increased with increasing rates of OF. The highest meter reading was in seedlings treated with 16.5 t/ha and least in seedlings without OF application (Table 4.35).

Table 4.34: Effects of Organic Fertiliser application rates on mean number of laterals of Yellow Passion Fruit seedlings in third pot experiment at Abeokuta in 2016

Organic Fertiliser (t/ha)	Weeks after transplanting		
	12	14	16
0	2.7	3.5	4.1
5.5	1.8	2.8	4.4
11.0	2.5	3.5	4.4
16.5	2.5	3.6	5.8
LSD (0.05)	1.42	1.21	3.42

LSD = Least significant difference

LSD = Least significant difference

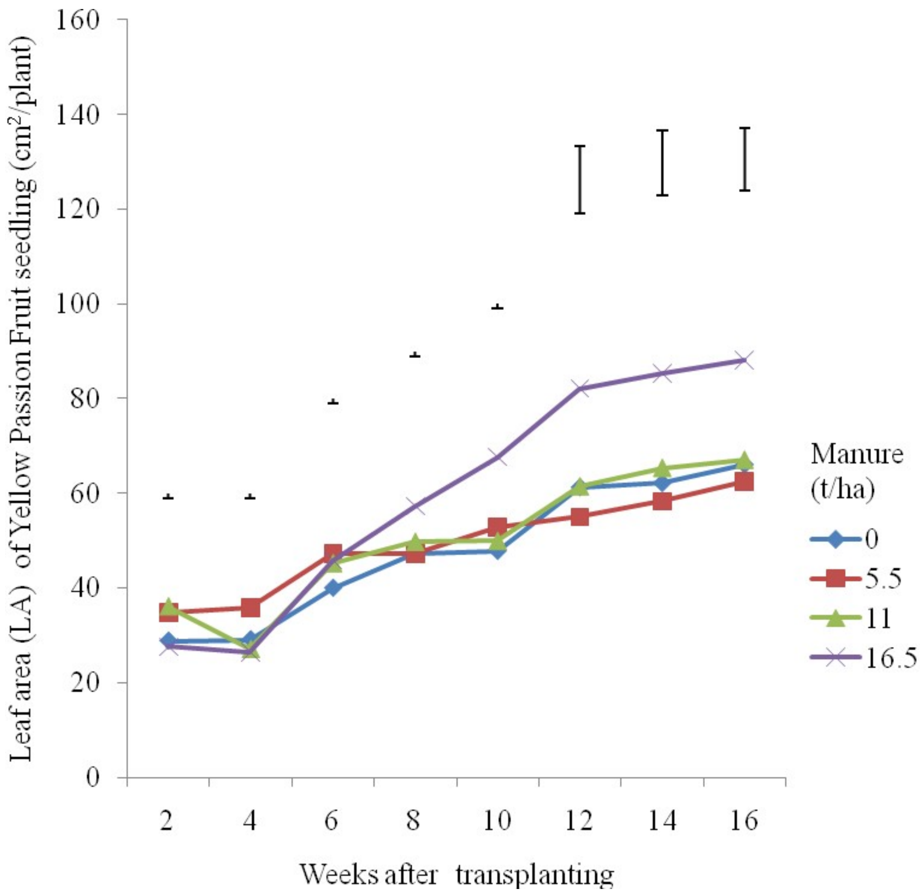

Figure 4.9: Effects of Organic Fertiliser application rates on leaf area (LA) cm^2 of YPF seedlings in third pot experiment at Abeokuta in 2016

Table 4.35: Effects of Organic Fertiliser rates on mean number of tendrils, foliar chlorophyll content and dry weight of Passion Fruit seedlings in third pot experiment at Abeokuta in 2016

	Weeks after transplanting								
	10	12	8	8	8	16	16	16	16
	Tendrils		Chlorophyll	Dry weight (g/plant)					
Organic Fertiliser (t/ha)				Leaf	Vine	Leaf	Vine	Tendrils	Root
0	5.8	12.2	39.3	8.97	8.87	29.63	38.93	3.53	10.93
5.5	3.1	7.2	40.8	4.63	3.03	27.47	33.83	2.40	9.43
11	2.6	7.4	41.7	1.30	1.99	31.57	39.60	2.50	8.67
16.5	4.8	13.6	59.3	2.86	1.70	37.60	33.73	3.13	11.80
LSD (0.05)	ns	ns	Ns	0.180	0.820	0.992	1.222	0.379	0.381

LSD = Least significant difference ($p \leq 0.05$) ns = not significant

(c) Dry weight (g/plant)

The dry weight of YPF seedlings was significantly influenced with the OF application rates. At 8 WAT the seedling without OF applied produced significantly highest leaf dry weight and vine dry weight compared to all OF rates. Yellow Passion Fruit seedlings treated with 5.5 t/ha OF had lower dry weights while seedlings treated with OF at 16.5 t/ha had least values.

At 16 WAT the leaf dry weight of YPF seedlings applied with OF at 16.5 t/ha had highest value, while seedlings that received OF at 11.0 t/ha and control had lower dry weights. Seedlings supplied with 5.5 t/ha OF had the least dry weight. The Yellow Passion Fruit seedlings vine dry weight was highest with OF applied at 11 t/ha. Control had lower value and 5.5 t/ha OF had lowest value.

At 16 WAT the seedling root dry weight increased significantly with increased OF application rates. Organic Fertiliser applied at 16.5 t/ha had highest value while control, 5.5 t/ha and 11.0 t/ha had similar but lower values (Table 4.35).

4.21 Effects of Organic Fertiliser Rates on Foliar Macronutrient Concentrations at 8 and 16 Weeks after Transplanting in Third Pot Experiment at Abeokuta in 2016

Macronutrient concentrations

At 8 WAT the Yellow Passion Fruit seedlings in control treatment had the highest P, K, Ca, and Mg foliar concentrations. Organic Fertiliser applied at 11.0 t/ha recorded significantly highest concentration of N compared to control (Table 4.37). The Control YPF seedlings had highest significantly different ($p \leq 0.05$) foliar P, K, Ca and Mg concentrations compared to concentration values obtained in seedlings treated with OF at various rates, which had lower similar values (Table 4.36).

At 16 WAT, control YPF seedlings and those treated with OF at 5.5 t/ha had highest foliar N concentration while other rates had lower similar values. Highest foliar P concentration was found in seedlings treated with OF at 5.5 t/ha while control had similar value with other OF rates. Highest foliar K concentration was obtained in seedlings added with OF at 11.0 t/ha.

Table 4.36: Foliar macronutrient concentrations (%) in seedlings of Yellow Passion Fruit 8 weeks after transplanting in the third pot experiment at Abeokuta in 2016

Organic Fertiliser (t/ha)	C	N	P	K	Ca	Mg
0	62.56^{ab}	1.42^{ab}	0.138^{a}	4.63^{a}	4.08^{a}	0.45^{a}
5.5	60.33^{b}	0.99^{c}	0.035^{b}	3.54^{ab}	1.73^{b}	0.09^{b}
11.0	67.33^{a}	1.83^{a}	0.056^{b}	1.17^{c}	1.37^{b}	0.01^{b}
16.5	61.34^{ab}	1.07^{b}	0.012^{c}	2.61^{b}	1.51^{b}	0.04^{b}

Means in a column with the same letters are not significantly different at $p \leq 0.05$

Organic Fertiliser applied at 5.5 t/ha and control had lower concentrations and least value occurred in seedlings treated with OF at 16.5 t/ha. Control YPF seedlings recorded highest concentration for foliar Ca and Mg. Application of OF at the different rates had significantly lower foliar Ca and Mg concentrations (Table 4.37).

4.22 Effects of Organic Fertiliser Rates on Foliar Micronutrient Concentrations at 8 and 16 Weeks after Transplanting in Third Pot Experiment at Abeokuta in 2016

Micronutrient concentrations

The micronutrients concentrations in the leaves of YPF seedlings increased over the period of observation. At 8 WAT YPF seedlings treated with 16.5 t/ha had highest foliar Fe concentration, followed by lower concentration in seedlings without OF application. Yellow Passion Fruit seedlings treated with OF at 5.5 t/ha recorded the lowest foliar Fe concentration. Yellow Passion Fruit seedlings without OF had highest foliar Mn concentration and seedlings with OF added at 11.0 t/ha had least. Similar trend was observed for foliar Zn concentration. Application of OF at 5.5 t/ha to the seedlings resulted in significantly highest foliar Cu concentration, followed by OF added at 16.5 t/ha and control had the least foliar Cu and Na concentration. At 16 WAT, YPF seedlings without OF had highest Fe and Zn concentrations while OF application at the various rates resulted in lower foliar Fe and Zn concentrations. Application of OF at 5.5 t/ha to the seedlings resulted in significantly highest foliar Mn concentration, followed by seedlings without OF and other rates had similar lowest concentrations. Application of OF was insignificant on foliar on Cu and Na concentrations (Tables 4.38 and 4.39).

4.23 Nutrients Concentration in Passion Fruit Seedlings Roots as Affected by Organic Fertiliser Application in Third Pot Experiment

(a) Macronutrient concentrations

There was increase in the root % C concentration of Passion Fruit seedlings with increasing rates of the applied Organic Fertiliser. At 8 weeks after the Organic Fertiliser application, seedlings without Organic Fertiliser had lowest value of 59.5% C and seedlings treated with Organic Fertiliser at 16.5 t/ha had significantly highest value of 73.0% C (Table 4.40).

Table 4.37: Foliar macronutrient concentrations (%) in seedlings of Yellow Passion Fruit 16 Weeks after transplanting in the third pot experiment at Abeokuta in 2016

OF (t/ha)	C	N	P	K	Ca	Mg
0	68.22^{ab}	1.85^{a}	0.014^{c}	4.34^{b}	5.59^{a}	0.65^{a}
5.5	68.56^{a}	1.85^{a}	0.070^{a}	4.77^{ab}	2.35^{b}	0.21^{b}
11.0	64.90^{b}	1.56^{b}	0.016^{c}	5.67^{a}	1.88^{c}	0.14^{c}
16.5	65.11^{abc}	1.70^{ab}	0.033^{b}	1.96^{c}	2.09^{bc}	$0.^{13c}$

Means in a column with the same letters are not significantly different at $p \leq 0.05$.

Table 4.38: Foliar micronutrients concentrations in seedlings of Yellow Passion Fruit 8 weeks after transplanting in the third pot experiment at Abeokuta in 2016

	Fe	Mn	Cu	Zn	Na
Organic Fertiliser (t/ha)	--------------------(mg/l)-----------------------				
0	202.5^{ab}	80.0^{a}	4.35^{b}	66.8^{a}	0.46^{ab}
5.5	34.9^{c}	54.0^{ab}	8.05^{a}	40.4^{b}	0.49^{a}
11.0	115.5^{b}	6.5^{c}	2.55^{c}	15.9^{c}	0.47^{ab}
16.5	490.0^{a}	25.5^{b}	5.50^{ab}	22.0^{bc}	0.46^{ab}

Means in a column with the same letters are not significantly different at $p \leq 0.05$).

Table 4.39: Foliar micronutrients concentrations (mg/l) in seedlings of Yellow Passion Fruit 16 weeks after transplanting in the third pot experiment at Abeokuta in 2016

Organic Fertiliser t/ha	Fe	Mn	Cu	Zn	Na
0	795.0^{a}	139.0^{b}	4.80	61.9^{a}	0.52
5.5	690.0^{b}	173.0^{a}	4.35	61.7^{ab}	0.53
11.0	695.0^{b}	127.0^{bc}	4.80	59.1^{b}	0.56
16.5	670.^{0c}	108.1^{c}	4.20	55.1^{c}	0.51

Means in a column with the same letters are not significantly different at $p \leq 0.05$.

Similar trend was observed in root %N concentration of seedlings treated with OF at 16.5 t/ha which had highest value of 2.27% and the control seedlings with least value of 0.5% N. The root concentrations of K decreased with increased rates of OF, application of OF at 5.5 t/ha to the seedlings resulted in 0.84% K but reduced to 0.13% at OF rate of 16.5 t/ha. Similar trends were observed for% Ca and Mg concentrations in the Passion Fruit roots with highest of 1.77% and 0.08% in control seedlings (Table 4.40).

At 16 weeks after OF application, carbon concentration in the roots increased with increased rates of OF (Table 4.41). The control treatment had significantly lowest value (57.30%) compared to plants that were treated with OF. Application of OF at rates 11.0 and 16.5 t/ha had highest carbon concentrations of 60.20% each while OF applied at 5.5 t/ha recorded comparable value of 58.60%. Similar trend was observed for K, control had least value of 0.84%, followed by 1.42%, 2.46% and 4.07% for OF at 5.5, 11.0 and 16.5 t/ha respectively.

The N concentration also increased with increasing OF rate up to 11.0 t/ha which had highest value of 0.85 % and control least 0.50%. The Ca concentration in the root was not significantly different but was highest (1.77%) in control treatment. The Mg concentration in the root was least in control but the plants that received OF had comparable values with highest concentration (0.15%) with OF 5.5 t/ha (Table 4.41).

(b) Micronutrient concentrations

At 8 WAT the highest significantly different Fe concentration occurred with OF applied at 5.5 t/ha, followed by control while other OF rates had significantly lowest concentration values. The root Mn concentration was highest in the control seedlings. It was observed that Mn concentration decreased significantly at increasing rates of OF. The root Mn concentration was highest in the control seedlings. It was observed that Mn concentration decreased significantly at increasing rates of OF. The root Mn concentration was highest in the control seedlings. It was observed that Mn concentration decreased significantly at increasing rates of OF. The root Zinc and Na concentrations were highest at OF rate 11.0 t/ha and least at 16.5 t/ha (Table 4.42).

Table 4.40: Macronutrient concentrations (%) in Yellow Passion Fruit seedlings Roots 8 weeks after transplanting in the third pot experiment at Abeokuta in 2016

Organic Fertiliser (t/ha)	C	N	P	K	Ca	Mg
0	59.46^{b}	0.64	0.013	0.83	1.77	0.08
5.5	59.83^{ab}	0.64	0.021	0.93	1.46	0.03
11.0	60.04^{ab}	0.71	0.054	0.46	1.58	0.03
16.5	73.00^{a}	2.27	0.047	0.13	1.35	0.01

Means in a column with the same letters are not significantly different at $p \leq 0.05$.

Table 4.41: Macronutrient concentrations (%)in Yellow Passion Fruit seedlings Root 16 weeks after transplanting in the third pot experiment at Abeokuta in 2016

OF (t /ha)	C	N	P	K	Ca	Mg
0	57.30^{b}	0.50^{c}	0.051^{b}	0.84^{d}	1.77	0.07^{b}
5.5	58.60^{ab}	0.64^{b}	0.064^{b}	1.42^{c}	1.65	0.15^{a}
11.0	60.20^{a}	0.85^{a}	0.145^{a}	2.46^{b}	1.47	0.10^{ab}
16.5	60.20^{a}	0.78^{ab}	0.040^{c}	4.07^{a}	1.69	0.10^{ab}

Means in a column with the same letters are not significantly different at $p \leq 0.05$

Table 4.42 Micronutrients concentrations (mg/l) in the Roots of Yellow Passion Fruit seedlings 8 weeks after transplanting in third pot experiment at Abeokuta in 2016

Organic Fertiliser t/ha	Fe	Mn	Cu	Zn	Na
0	$336.^{5b}$	107.5^{a}	8.85^{ab}	33.3^{b}	0.38^{ab}
5.5	765.0^{a}	88.5^{ab}	9.95^{a}	38.2^{ab}	0.37^{ab}
11.0	83.5^{d}	82.0^{b}	6.10^{b}	40.7^{a}	0.48^{a}
16.5	103.0^{c}	5.0^{c}	1.50^{c}	12.5^{c}	0.34^{b}

Means in a column with the same letters are not significantly different at ($p \leq 0.05$).

At 16 weeks after transplanting, micronutrients in the root of Yellow Passion Fruit seedlings varied with the treatments. The highest Fe concentration was obtained in seedlings supplied with OF at 5.5 t/ha and least in the seedlings treated with OF at 11.0 t/ha. Control and O applied at 16.5 t/ha had comparable root Fe concentrations. Similar trends were observed for root Mn and Na concentrations. Highest root Cu concentration was in seedlings treated with 11.0 t/ha of OF and for Zn seedlings the received OF at 16.5 t/ha (Table 4.43).

4.24 Effects of the Organic Fertiliser Rates on Vegetative and Reproductive Growth Responses of Yellow Passion Fruit Under field condition at Siun in 2011 and 2012

(a) Numbers of laterals and trusses of Yellow Passion Fruit

Yellow Passion Fruit plants treated with OF at 2.5 t/ha had significantly highest number of laterals. This was comparable to other OF rates and the control seedlings recorded the least number of laterals. The number of trusses of YPF seedlings was not significantly affected by OF application. However YPF plants that were treated with OF recorded higher values compared to plants without OF which recorded least value (Tables 4.44 and 4.45).

(b) Number of flower buds per plant of Yellow Passion Fruit plants

Flower-bud formation in Yellow Passion Fruit plants started at 20 WAT. The number peaked between 24 and 36 WAT in plants treated with OF irrespective of the rate of application. Organic Fertiliser applied at 0.5 t/ha and 1.5 t/ha had similar trend of flower bud production up to 44 WAT and then there was reduction. Yellow Passion Fruit plants treated with OF at 0.5 t/ha produced significantly highest number of flower buds. The plants treated with OF 2.5 t/ha had lower number of buds. However at 52 WAT there was sporadic increase in number of flower buds which was similar to plants applied with OF at 1.5 t/ha at 48 WAT. Control plants had consistently lowest number of flower buds (Figure 4.10).

(c) Numbers of flower and fruit produced per plant of Yellow Passion Fruit

The control plants produced flowers between 52 and 64 WAT with the highest occurrence at 60WAT and there was no fruit formation throughout.

Table 4.43: Micronutrients concentrations (mg/l) in the roots of Passion Fruit seedlings 16 weeks after Organic Fertiliser application in third pot experiment at Abeokuta in 2016

Organic Fertiliser t/ha	Fe	Mn	Cu	Zn	Na
0	1330.0^{bc}	110.0^{b}	5.70^{c}	26.4^{c}	0.39^{b}
5.5	2655.0^{a}	267.5^{a}	11.25^{b}	81.5^{b}	0.59^{a}
11.0	1250.0^{c}	111.5^{b}	29.35^{a}	80.1^{b}	0.48^{ab}
16.5	1775.0^{b}	157.0^{ab}	11.90^{b}	214.5^{a}	0.40^{b}

Means in a column with the same letters are not significantly different at ($p \leq 0.05$).

Table 4.44: Effects of Organic Fertiliser application rates on number of laterals per plant of Yellow Passion Fruit under field condition at Siun in 2011

	Weeks after transplanting						
Organic Fertiliser t/ha	12	20	28	36	44	52	60
0	2[b]	2[b]	2[b]	2[b]	3[b]	3[c]	3[c]
0.5	4[b]	4[b]	6[b]	6[b]	6[b]	7[b]	7[b]
1.5	4[b]	5[ab]	6[b]	6[b]	6[b]	7[b]	7[b]
2.5	11[a]	11[a]	13[a]	13[a]	13[a]	15[a]	15[a]
SE	2.0	2.00	1.72	1.72	1.72	1.72	1.72

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Table 4.45: Effects of Organic Fertiliser on rates number of trusses per plant of Yellow Passion Fruit under field condition at Siun in 2011

	Weeks after transplanting						
Organic Fertiliser (t/ha)	12	20	28	36	44	52	60
0	2	2	2	2	2	2	2
0.5	4	4	4	4	4	4	4
1.5	3	3	3	3	3	3	3
2.5	3	3	3	3	3	3	3
SE	1.1	1.1	1.1	1.1	1.1	1.1	1.1

SE = Standard error of mean

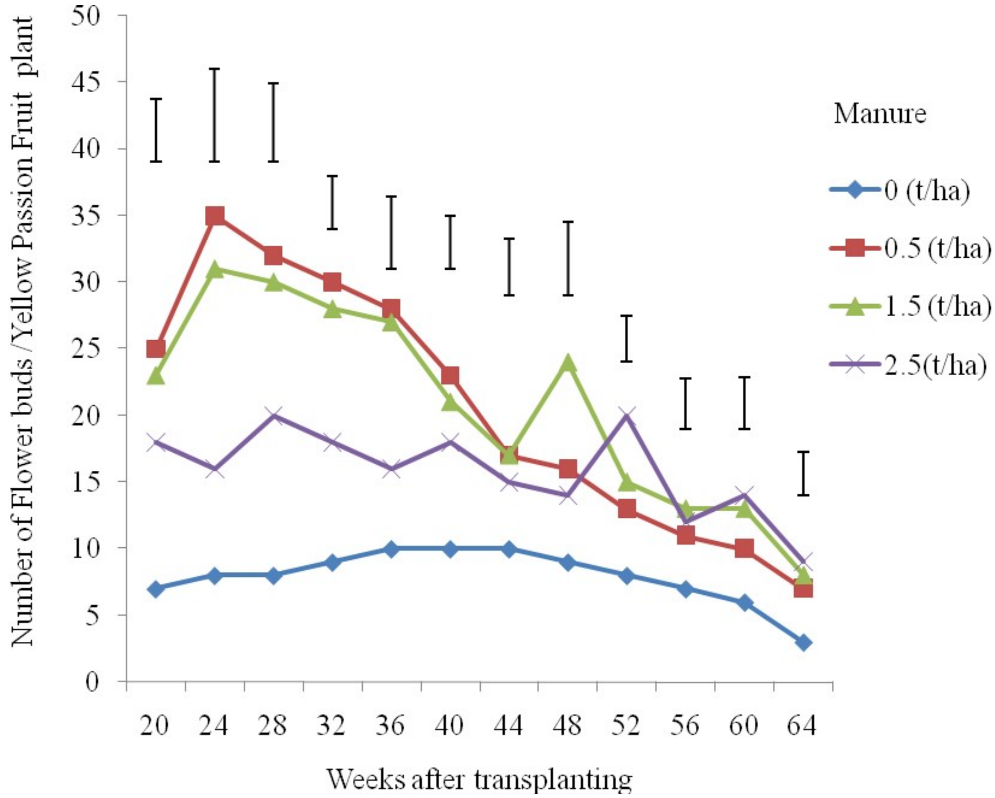

Figure 4.10: Flower buds production in YPF from 20 to 64 weeks after transplanting as influenced by Organic Fertiliser application at Siun in 2012
I = SE = Standard error of mean bar at $p \leq 0.05$

Flower formation commenced at 52 WAT in YPF that received OF at 0.5 t/ha and increased till 60 WAT but dropped 64 and 80 WAT. Plants applied with OFat 1.5 t/ha commenced flower production from 56 WAT up till 80 WAT. The highest number of flowers was consistent between 64 and 80 WAT. Flower production with application of OF at 2.5 t/ha presented similar trend with 1.5 t/ha application rate.

Fruit formation commenced at 60 WAT and the number increased rapidly till 64 WAT, stabilised between 64 and 76 WAT and then increased at 80WAT. Fruit formation in Yellow Passion Fruit treated with OF at 1.5 t/ha commenced at 64 WAT and the number of fruits increased till 80 WAT (Figure 4.11 a-d).

(d) Percent Flower abortion and Fruit set per plant in Yellow Passion Fruit

In cotrol plants 100% flower abortion was recoded between 56 and 80 WAT, hence the % fruit set was nil. Plants treated with OF at 0.5 t/ha recorded highest % flower abortion at 56 WAT but decreased steadly while the % fruit set increased from 56 WAT till 80 WAT. Similar trends were observed in plants treated with OF at 1.5 and 2.5t.ha. There was initial high % flower abortion between 62 and 60 WAT which subsequently decreased. The trend for % fruit set was opposite of the trend for lfower abortion. The % fruit set increased steadily from 60 WAT till 80 WAT while % flower abortion decreased (Figure 4.12a-d)

4.25 Effects of Organic Fertiliser Application on Fruit Yield per Plant of Yellow Passion Fruit

At first harvest, OF application at 0.5 t/ha recorded the highest percentage fruit yield, which was significantly different from other OF rates. Organic Fertiliser added at 1.5 and 2.5 t/ha had lowest % fruit yield. This trend was prevalent throughout the period of harvest with exception at second harvest at 64 WAT.

At second harvest, the % fruit yields of Yellow Passion Fruit plants added with OF at 1.5 and 2.5 t/ha were similar accounting for approximately 40 and 38% respectively. Since control failed to produce flower there was no yield recorded throughout the period of observation (Figure 4.13).

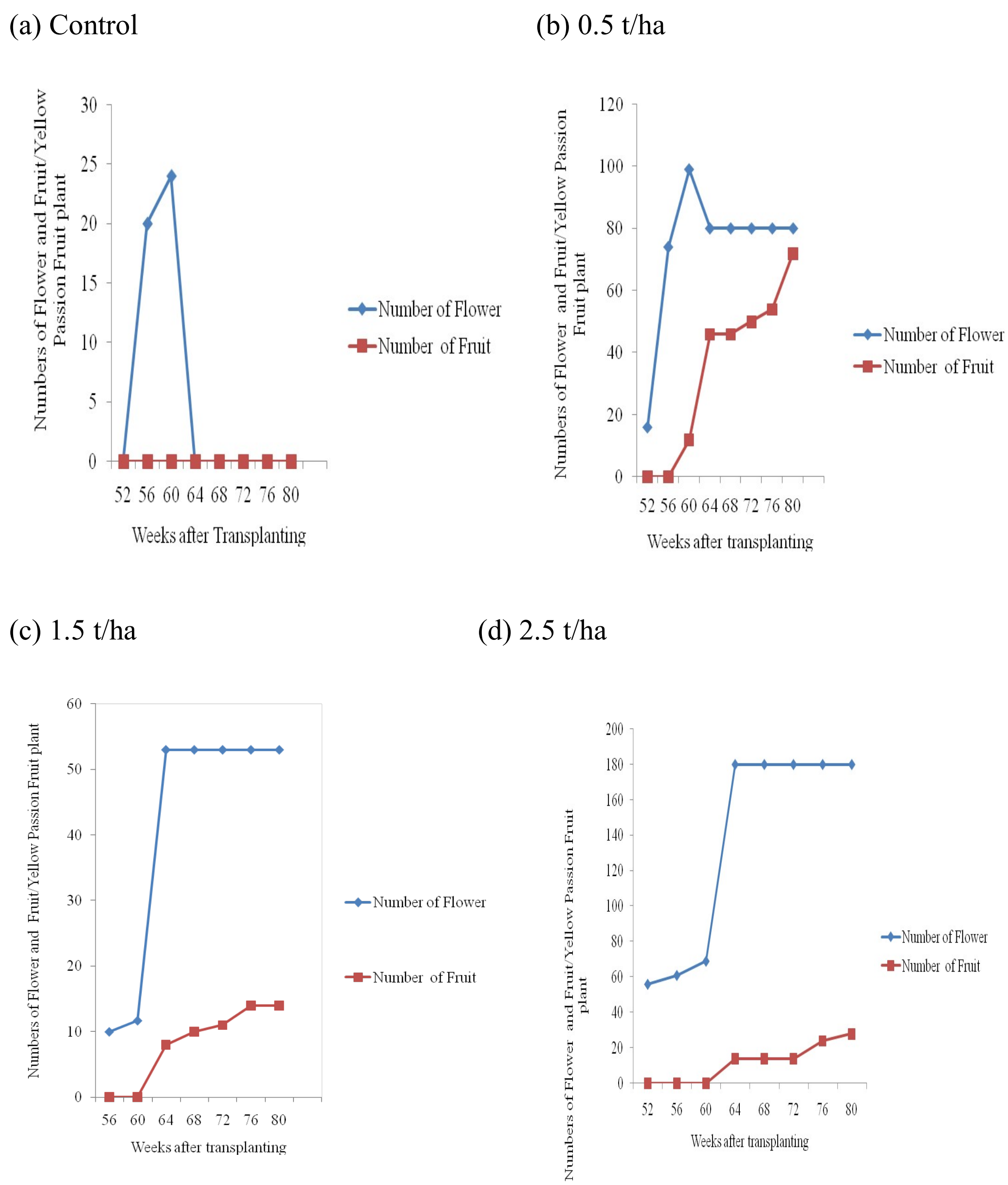

Figure 4.11 Effects of Organic Fertiliser application on numbers of flowers and fruits per plant of Yellow Passion Fruit under field condition at Siun in 2012

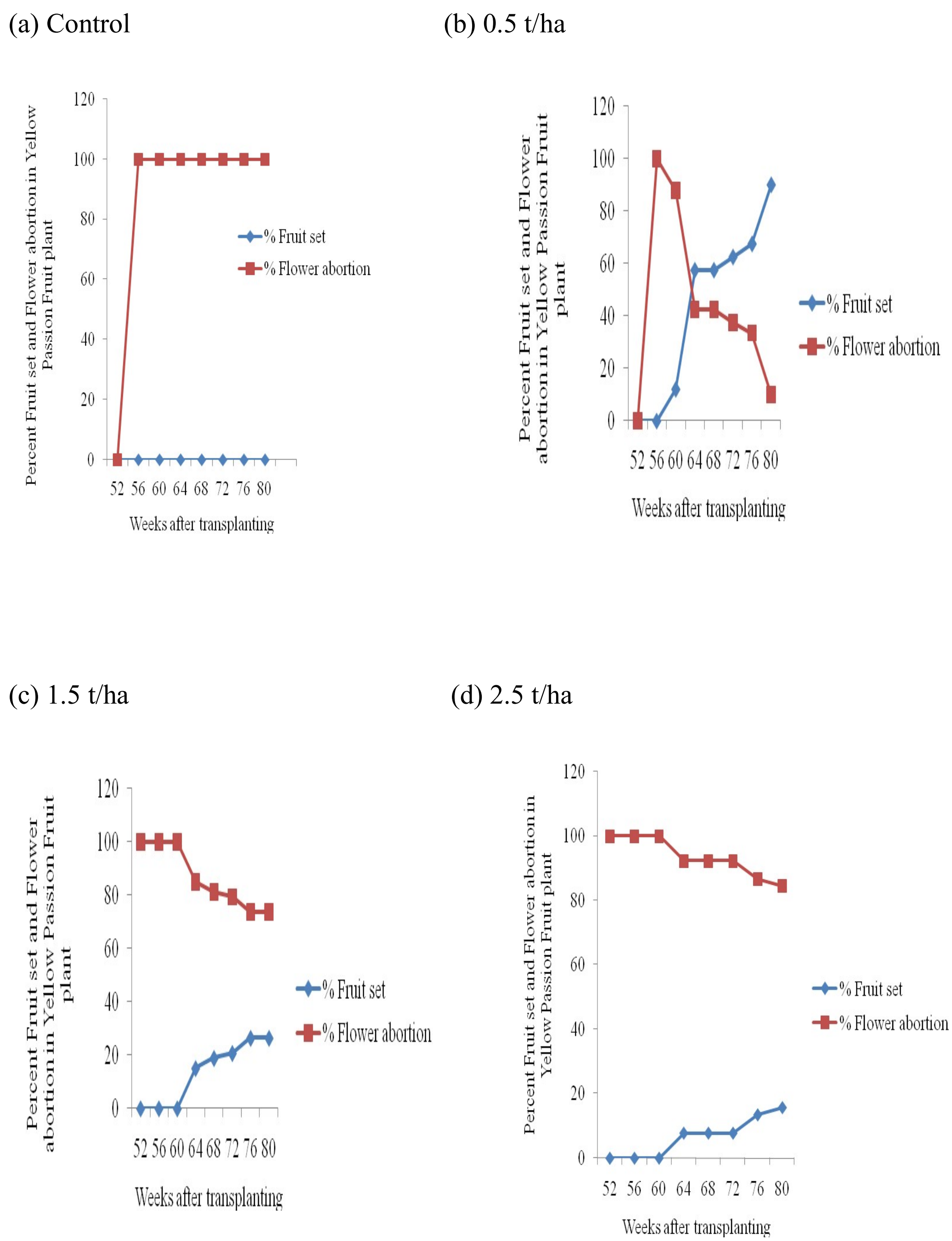

Figure 4.12: Effects of Organic Fertiliser application on percent Flower abortion and Fruit set in Yellow Passion Fruit under field condition at Siun in 2012

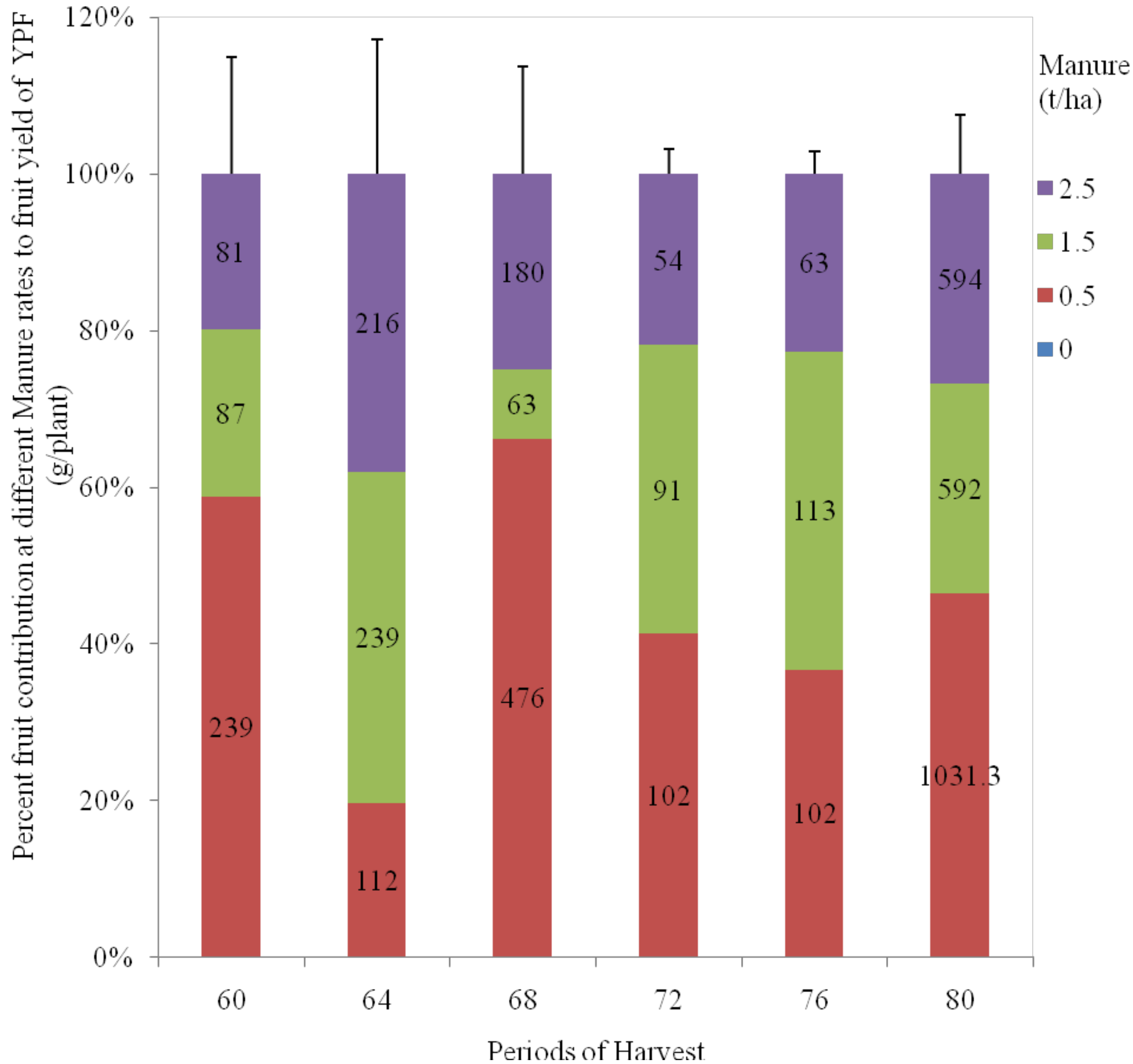

Figure 4.13: Effects of Organic Fertiliser application on Fruit yield (g/plant) of Yellow Passion Fruit at Siun in 2012

The cumulative fruit yield from plants treated with OF at 0.5 t/ha was the highest and significantly different from other rates which had similar values. This yield from plants treated with OF at 0.5 t/ha accounted for about 50% of the cumulative yield. The Yellow Passion Fruit without OF did not produce any fruit throughout the period of observation (Figure 4.14).

4.26 Cash Benefits of Yellow Passion Fruit Production under Different Organic Fertiliser Rates at Siun in 2012

The TFC was the same for Yellow Passion Fruit production under all the applied treatments. The TVC increased the as the OF rates increased thereby leading to increased TC.

The economic analysis showed that TR was highest with OF applied at 0.5 t/ha. Higher rates of OF had lower TR and the control recorded the least TR for Yellow Passion Fruit production.

The % TFC was highest in control treatment but reduced with increased OF application. The % TVC was highest at OF rate of 0.5 t/ha while other rates had similar % but control had the least %.

The Cash Benefit was highest with application of OF at 0.5 t/ha. Other OF rates had lower but similar values and control recorded the lowest.

The Cost-Benefit (CB) ratio per unit production of YPF was least in OF applied at 0.5 t/ha. Subsequent increase in rates of OF only resulted in increased cost per unit production. Control treatment had the highest cost per unit production YPF (Tables 4.46-4.49).

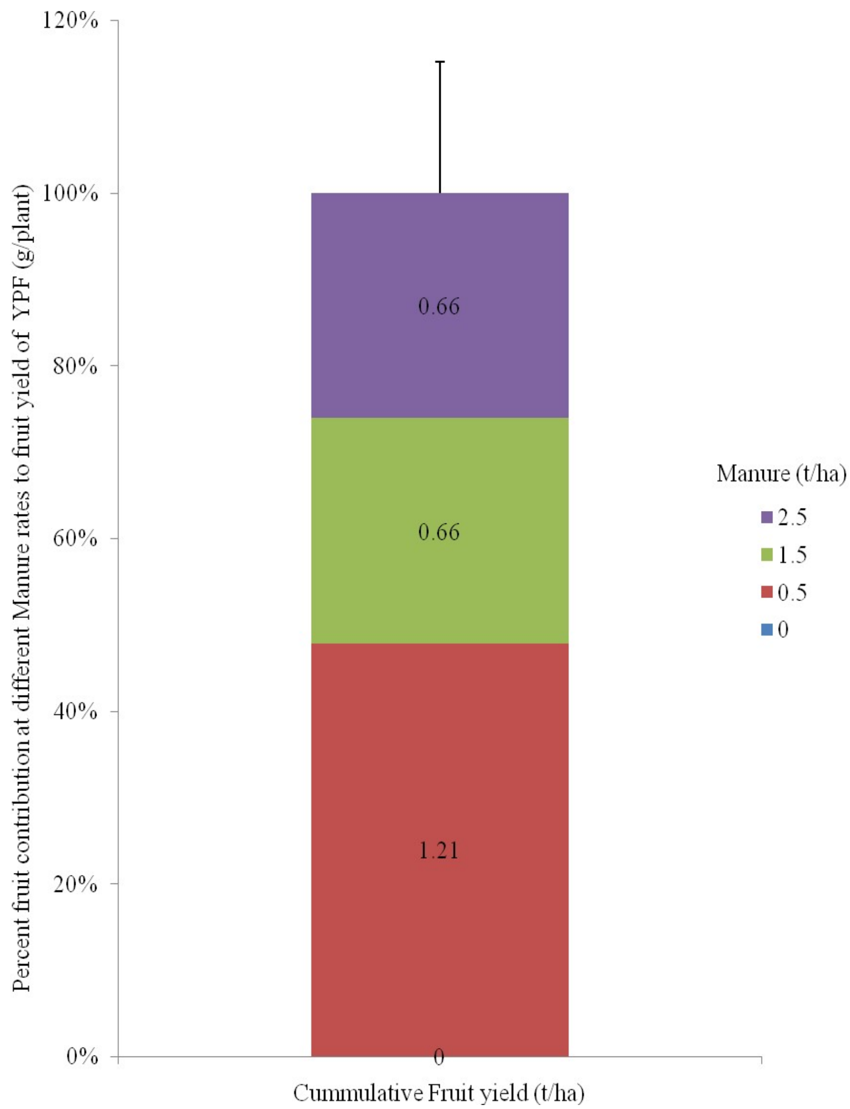

Figure 4.14: Effects of Organic Fertiliser Application on Cumulative Fruit Yield (t/ha) of Yellow Passion Fruit at Siun in 2012

Table 4.46: Total fixed cost (TFC) estimate/ha for Yellow Passion Fruit production at Siun in 2012

	Item	No	Unit Price (₦)	Control	Organic Fertiliser (t/ha)		
					0.5 t/ha	1.5 t/ha	2.5 t/ha
				₦	₦	₦	₦
1	Land rentage (5 years)	1ha	6,000/yr	30,000	30,000	30,000	30,000
2	Water pump with hose	1	5,000/yr	25.000	25,000	25,000	25,000
3	Medium knapsack	1	8,000	8,000	8,000	8,000	8,000
4	Hoes	2	750	1,500	1,500	1,500	1,500
5	Rubber boot	1 pair	1,500	1,500	1,500	1,500	1,500
6	Buckets	4	300	1,200	1,200	1,200	1,200
7	Rakes	1	450	450	450	450	450
8	Watering can	2	400	800	800	800	800
9	Shovel	1	1,200	1,200	1,200	1,200	1,200
10	Garden fork.(set)	1	500	5,000	5,000	5,000	5,000
11	Weighing scale	1	13,000	13,000	13,000	13,000	13,000
12	Posts/ha	100	100	10,000	10,000	10,000	10,000
13	Trellis wire bundle	4	2,000	8,000	8,000	8,000	8,000
14	Passion Fruit seedlings	1111	50	55,000	55,000	55,000	55,000
15	Maintenance cost		5,000/yr	25,000	25,000	25,000	25,000
16	**Total fixed cost (TFC)**			185,650	185,650	185,650	185,650

Assumptions:

i. The estimated cost of item No 2 is the depreciated value per annum

ii. Item No 15 is required for servicing of fixed assets as at when due

iii. Items 3 to 15 will be totally depreciated over the lifespan (6 years) of the crop

Table 4.47: Total Cost (TC) Estimate/ha for YPF Production over a Period of 5 years

	Item	No of item	Unit Price (₦)	Control	Organic Fertiliser (t/ha)		
					0.5 t/ha	1.5 t/ha	2.5 t/ha
				₦	₦	₦	₦
17	Ploughing	1 ha	10,000	10,000	10,000	10,000	10,000
18	Poly vinyl Twine (rolls)	40	50	2,000	2,000	2,000	2,000
19	Transportation (trip)	1	2,500	2,500	2,500	2,500	2,500
20	Layout and hole digging	1ha	5,000	5,000	5,000	5,000	5,000
21	OF usage (t/ha/yr)	1ha	2,000	0	5,000	15000	25,000
22	Seedling transplanting	1ha	3,000	3,000	3,000	3,000	3,000
23	Posts erection (Trellis)	1ha	5,000	5,000	5,000	5,000	5,000
24	Weeding/yr	3/yr	10,000	30,000	30,000	30,000	30,000
25	Vine maintenance/ Pruning	1/yr	1,000	5,000	5,000	5,000	5,000
26	Water supplementation	6 wks	1,500	9,000	9,000	9,000	9,000
27	Harvesting	50kg	750	46,100	853,050	465,300	465,300
28	Sunshine organic fertilizer (50kg)	1	1,000	0	10,000	30,000	50,000
29	Organic biocide (1L)	1	1,200	1,200	1,200	1,200	1,200
30	Total variable cost			118,800	945,750	583,000	613,000
31	Interest on capital spent	1	8 %/yr	9,504	75,660	46,640	49,040
32	**Total cost**			313,954	1,207,060	815,290	847,690

Assumptions

I. All Labour charges based on negotiation not man-day hour

ii. OF application is done per tonne per ha yearly over a period of 5 years

iii. Water is from nearby source and the cost is the fuelling and operator's charge

iv. Harvest charge is per 50kg of marketable fruits harvested each season

v. Projected yield is based on biological yield from this study presented in Table 4.49

vi. Sales is on the farm so no handling or haulage expenses

vii. Total Cost (TC) = Total Fixed Cost (TFC) + Total Variable Cost (TVC) + Interest on capital

Table 4.48: Projected yield estimate for 6 years of Yellow Passion Fruit in Abeokuta

Year	Yield (t/ha)			
	Control	Organic Fertiliser (t/ha)		
		0.5	1.5	2.5
First year	0	1.21	0.66	0.66
Second year	0.10	2.42	1.32	1.32
Third year	0.20	4.84	2.64	2.64
Fourth year	0.40	9.68	5.28	5.28
Fifth year	0.80	19.36	10.56	10.56
Sixth year	1.60	19.36	10.56	10.56
Projected cumulative yield	3.10	56.87	31.02	31.02

Assumptions:

i. Projected yield is based on the first year experience in this study

ii. Yield doubles yearly to the fifth year and stable in the sixth year

iii.100% plant survival

Table 4.49: Cash Benefit of Yellow Passion Fruit production in Siun/Abeokuta, Ogun state as affected by Organic Fertiliser rates

		Unit Price (₦)	Control	Organic Fertiliser (t/ha)		
				0.5 t/ha	1.5 t/ha	2.5 t/ha
33	Total Revenue (₦)	250/kg	775000	14,217,500	5,755,000	5,755,000
25	Cash Benefit (₦)		461046	13010440	4939710	4907310
26	% TFC		59.13	15.38	22.77	21.90
27	% TVC		40.87	84.62	77.23	78.09
28	Benefit-Cost ratio		0.4	0.08	0.14	0.15

Cash Benefit = TR-TC

Percentage of TFC = TFC/TC × 100

Percentage of TVC = TVC/TC × 100

Assumption: Total Revenue is based on sales of fruits only

CHAPTER 5

5.0 DISCUSSION

The low soil fertility status that was improved with the application of Organic Fertiliser is in line with the earlier reports on use of Organic Fertilisers in soil maintenance. These improvement in soil fertility was due to exertion of favourable effects on the soil structure by Irganic fertilise, r increased water holding capacity, and water infiltration (Avnimelech, 1986; Broadbent, 1986; Sims, 1996; Atiyeh *et al.,* 2000). The soil pH that was altered from acidic to alkaline with increased rates of Organic Fertiliser might be due to low soil Mn content. This corroborates findings of Ogunwale *et al.*, 2005, who found that soils deficient in Mn were characterized by high pH with accompanied high soluble organic matter content. The experimental site soil was of low fertility status which is typical of most Nigerian soils. This supports the findings of Mba, (1996) who stated that most tropical soils are characterized by lack of adequate plant nutrients, decline in soil fertility due to nutrient removal exceeding nutrient addition either as Organic or mineral fertilisers.

Responses of Yellow Passion Fruit seedlings that were observed two months after Organic Fertiliser application can be attributed to time taken for Organic Fertiliser to mineralise and release the nutrients. This observation is consistent with earlier findings of Singh *et al.* (1980); Menzel *et al*. (1991) who reported enhanced growth attributes post manure application. This period possibly coincided with the peak of OF mineralisation which is crucial to perennial crops like the Yellow Passion Fruit to benefit from. Soil qualities like pH, available nutrients, texture, organic matter content and water relationships have direct effects on crop growth and development as evidenced by increased growth in seedlings treated with Organic fertiliser. The improved growth response affirmed the findings of Hornick, (1992); Olubode and Fawusi, (1998); Aruleba and Fasina, (2004), Berberich *et al*., (2006) who reported that young plants developed large amounts of vegetative and root growth in response to adequate soil qualities occasioned by soil amendment.

The depressed growth in seedlings beyond 1.5t/ha in the pot experiments may be as result of nutrient toxicity. The mind-set that excessive application of Organic

Fertiliser or compost to the soil is not detrimental is misleading. Mangan, (2016) buttressed this stance by stating that excessive fertiliser application can create many problems; the most common ones with optimum nutrient levels are accumulation of high soluble salts, excessive organic matter and too low or high soil pH levels. It was further stated that the use of soil organic matter, which provides many positive attributes to soils used for crop production, becomes detrimental when in excess level of above 8%; it leads to excessive nutrient availability and other problems. The problem of nutrient imbalance characterised by antagonism as opposed to synergism of the nutrients can also affect plant growth negatively. The lower Mn content in the soil could have inhibited the N uptake by the seedlings which are necessary for foliage development.

The failure of control treatment to produce fruits on the field could be attributed to inability of the initial soil fertility to support growth beyond the vegetative phase. For most crops the vegetative phase controls the biological and economic yields since photosynthates formed during growth phase are partitioned into the seeds and other storage organs. It has been stated that young plants possess ability to absorb double nutrients for growth but mature plants which approach reproductive stage less (Huett and Dirou, 2000). Earlier reports on low soil nutrient contents supported this as major problem of low crops yield (Hauser and Kang, 1993; Ogunwale *et al.*, 2005).

The low K status in the soil prior to planting could be implicated for failure of control seedlings to form fruits which corroborates the importance of K as crucial to fruit formation. This is in line with the report of Joy (2011) that Passion Fruit growth and production require an adequate nutritional state at all stages of growth with a fertiliser application plan that permits the maintenance of an adequate nutritional state for the crop. This can be further buttressed by the fact that there is great demand for energy by the plant for the strong translocation of nutrients from the leaves to the development of fruits from the onset of fruit formation. The formation of higher flower buds in seedlings treated with Organic fertiliser could be as a result of improved fertility status which sustained them beyond juvenile phase. This may be due to the superiority of organic fertiliser with the slow release of the balanced nutrients reserves during decomposition and mineralisation over time for plant use. The mineral nutrients in Organic Fertiliser are protected by binding and adsorptive property of organic matter component which accounts for slow release of nutrients in the soil and reduction of nutrient losses (Adeoye *et al.*, 1993). With respect to superior flower, fruit and fruit yield with application of Organic Fertiliser, Damato *et al.* (2005) reported better results with Organic Fertiliser on development, production and fruit quality of sweet Passion Fruit *(Passiflora alata* Dryland). Similar trend was observed by Britto *et al.* (2005) with Organic Fertiliser fortified with Potassium applied to Yellow Passion Fruit. They found that the plant developed adequate attributes for consumption of its fruit juice. This buttressed earlier work of Adeoye *et al*. (1993) who observed improved crop performance in terms of yield and quality of maize fertilized with Pacesetter Organo-mineral fertilizer. The enhanced reproductive development of Yellow Passion Fruit lower Organic Fertiliser application rate compared to other rates and control is line with the assertion of Mangan, (2016) that excessive Organic Fertiliser or compost could be detrimental to crop and resource wastage. In line with this opinion Adeoye *et al*. (1993) opined that it is important consideration for economics of fertiliser use to avoid excessive use. The earliness of YPF applied with Organic Fertiliser at 0.5 t/ha in producing flowers and subsequent higher cumulative yield justified the foregoing.

The observed varied trends in nutrient uptakes in Yellow Passion Fruit confirmed the earlier documented findings that the effects of applied fertilisers absorption is extremely complex in horticultural crop' for growth and yield. Earlier workers found that nutrient uptakes are influenced by many factors that may have both antagonistic and synergetic effects on each other (Kader *et al*., 1987; Fagbayide, 1995, Joseph-Adekunle, 2006). The high positive and significant correlation exhibited in total uptakes of phosphorus and nitrogen with K corroborates the findings Fagbayide, (1995) who found that though the P requirement of plants is far less than that of N and K, is essential for fruit formation. Phosphate uptake was indicated to be higher during the flowering, seed filling stage as well as the stage of highest photo-synthetically active number of leaves. The trend observed in the correlation of the Organic fertiliser rates and the growth attributes confirmed the opinion of Agboola and Corey, (1973); Fageria, (2001), that ability to track nutrient uptake at the vegetative phase of a crop could be a useful tool to predict the eventual yield.

The negative effect of exchangeable Mg and percent K observed in seedlings can be attributed to antagonism; which is the inhibition of one element on the uptake of the other. Extent of the antagonism depends on the concentration of these elements; as further substantiated by negative correlation between percent K and percent Ca but stimulating with percent Mn. Yellow Passion Fruit as a shallow rooted plant can take advantage of concentration of the nutrients in the organic matter accumulated in the topsoil. However with excessive application of Organic Fertiliser to the soil there could be excessive concentration in the soil. As pointed by Wu and Saise (1989), Abiola (2007), this could also possibly be responsible for the observed detrimental effects of applied Organic Fertiliser rates on growth of Passion Fruit in which case there could have been excessive nutrients in the top soil This assertion confirmed the earlier statement of Mengel and Kirkby (1982) that extremely high levels of nutrient supply impaired growth whereas too little resulted in severe deficiency, little levels resulted in mild deficiency; sufficient levels in luxury range and too much in toxic range.

The right combination could have influence on Total Dry Weight of crops. The application of Organic Fertiliser at 0.5 t/ha was found to be adequate for both vegetative and reproductive phases of Yellow Passion Fruit in Abeokuta and Siun in Ogun state; and above 2.0 t/ha was deleterious at the juvenile phase. The observed vegetative growth depression in Yellow Passion Fruit plants with increased rates of Organic Fertiliser was due to nutrient imbalance. This is in line with assertion of UMass (2017), that maintaining optimum nutrients level which is a range at which plant growth is maximized is critical to crops. Nutrient levels that are above optimum do not improve plant growth. Excessive and indiscriminate addition of Organic Fertiliser with mind-set that it cannot be over applied results in adverse effects on plant growth, increases the potential for environmental contamination due to leaching, and represents a waste of resources.

The positive and significant correlation of uptakes of Cu, Mg and Mn with N uptakes contributed significantly to the Total Dry Weight than any other nutrient. There is need to critically consider the N ratio to these other nutrients in fertiliser formulation for YPF. This is in line with assumption that nutrient interaction in crops occurs when the supply of one nutrient affects the absorption and utilization of others (Fageria *et al*., 1997). Shukla (2009) reported that addition of plant residues or litters has been found to have multi-beneficial effects on the soil which included maintenance of good soil physical conditions; organic matter, provision of nutrients and stimulation of biological activities in soils. Positive correlation had been reported to exist between leaf P and soil pH, available P and Mg but antagonistic for Ca. Potassium in the plant is a function of soil pH, soil organic matter and exchangeable Mg.

To achieve these goals, there must be optimum management of the fertiliser applied vis-à-vis the crop nutrient requirements as well as soil testing to predict fertiliser needs. Healthy plant leaves contain between 2.0 and 5.0% N on a dry weight basis but deficiencies of N result when inadequate quantities are applied or there are errors in fertiliser management leading to insufficient N supply to the crops. It has been reported that in commercial vegetable production, there is a problem from excess N application (Hochmuth *et al*., 2015). Plants treated with excess N present varied growth disorder such as *"bullish"* growth or thick, leathery leaves that curl under in dramatic fashion producing compact growth especially in warm and sunny conditions (Hochmuth *et al.,* 2015). The increasing concentration of macronutrients especially foliar N with increasing rates of Organic Fertiliser over time showed that the Passion Fruit could benefit maximally from the Organic Fertiliser as growth progresses.

There is a general concentration range for each essential element that results in normal plant growth called the adequate or sufficient nutritional concentration range. When the range of concentrations is within the zone of sufficiency, plant growth remains relatively constant. The critical concentration occurs at the point where growth is reduced by 10% due to a shortage of the element in question. The critical concentrations for an element for crop growth can be different depending on stage of growth and plant part used for the analysis. The zone sufficiency refers to a situation where an increase in tissue nutrient concentration is not accompanied by an increase in growth. The K content in the Organic Fertiliser should be adjusted or supplemented and application made to coincide with the onset of flowering and fruiting of Yellow Passion Fruit to ensure good yield. Further addition of fertiliser can result in over fertilisation and resulting in luxury consumption of nutrients by the plant. Beyond this is the toxicity zone where tissue elemental concentrations are greater than those in the adequate zone. Gradual decrease in plant growth occurs in the toxicity zone. As the tissue concentrations rise further, toxicity symptoms, often necrosis appear. This is in line with observation at 8 WAT in which the leaves of Yellow Passion Fruit seedlings became necrotic and dropped and later developed new leaves. Improved fertilizer management for crop production is important in view of economics of production costs, conservation of natural resources, and reduction of possible negative environmental impacts that could arise from fertiliser usage.

The highest Benefit –Cost Ratio (BCR) recorded at lowest Organic Fertiliser rate indicated that Yellow Passion Fruit production could be profitable with 0.5t/ha level of Organic fertiliser. It helps in evaluating and comparing individual resource, development activities, projects or programs. The importance of BCR cannot be overemphasised and its proper interpretation is germane to avoid misleading decision as opined by George, (1971).

CHAPTER 6

6.0 SUMMARY AND CONCLUSIONS

The climatic condition in southwest Nigeria is conducive for cultivation of Yellow Passion Fruit apart from the location of many fruit juice industries. Despite these endowments, there is no substantial cultivation nor has the crop received research attention as have been enjoyed over the years by other fruit tree crops. It is on the backdrop of introducing its establishment and cultivation into the crop production of the zone that this study was embarked upon. This study addressed its nutrients requirement for successful cultivation using Organic Fertiliser. The influence of the Organic Fertiliser at different levels on vegetative growth and reproductive responses; soil nutrients and plant dynamics, yield components, fruit yield and cash benefits of Yellow Passion Fruit in Abeokuta, south western Nigeria were examined.

The study consisted of three pot experiments each spanning a period of 4 months and one field experiment that lasted 24 months. The pot experiments conducted in 2009, 2010 and 2016 examined different Organic Fertiliser rates based on the soil critical levels of N, P and K. Thereafter, the Organic Fertiliser rates were tied to the N and K need of Passion Fruit. The first experiment examined the effects of Organic Fertiliser rates at 0, 0.5, 1.0, 1.5, 2.0 and 2.5 t/ha, second pot experiment evaluated Organic Fertiliser rates at 0, 0.3, 0.6, 0.9, 1.2, 1.5, 1.8, 2.1, 2.4, 2.7.and 3.0 t/ha while the third one examined Organic Fertiliser at 0, 5.5, 11.0 and 16.5 t/ha. Seedlings at four-month old were transplanted at the rate of one seedling per pot filled with top soil of between 5-20 kg/pot. Vegetative growth responses were monitored in each of the experiment. The effects of the applied Organic Fertiliser on soil nutrients dynamics and plant nutrient concentrations and uptakes were assessed. The best Organic Fertiliser rate from these pot experiments was selected, scaled up and evaluated under field condition at 0, 0.5, 1.5 and 2.5 t/ha. Four-month old seedlings were transplanted at 3 x 3 m spacing and one seedling per stand. The vegetative growth and yield of Passion Fruit under the varying Sunshine Organic Fertilizer® rates were examined. The Cost-

Benefit analysis of Yellow Passion Fruit cultivation under organic production system was assessed.

The effects of Organic Fertiliser rates on vegetative growth, yield components and yield of Yellow Passion Fruit varied and were enhanced at lower Organic Fertiliser rates of 0.5-1.5 t/ha The soil nutrient status increased but above 2.0 t/ha led to toxicity and antagonism expressed in the depressed vegetative growth of juvenile Yellow Passion Fruit. Nutrient content and uptake increased linearly up to the 2.0 t/ha Organic Fertiliser for N, P, K, Zn, Fe uptake but curvilinear for Cu, Mg and Mn.

The fruit yield was higher with application of Organic Fertiliser at 0.5 t/ha (1.21t /ha) compared to 0.660t /ha for applied Organic Fertiliser at 1.5 and 2.5 t/ha each and control treatment produced no fruits. The acidic and low fertility soil status was changed to alkaline with higher nutrient contents. The addition of Organic Fertiliser at higher rates led to antagonistic and stimulating interactions of the nutrients which led to nutrient imbalance reflected in vegetative growth depression. It is suggested that application of Organic Fertiliser can be done in split doses to coincide with the critical phenological growth stages and reproductive development stages such as on set of flowering of the crop.

The cost-benefit analysis in the first year of production showed deficits for control only. The projected yield from the second year indicated that Yellow Passion Fruit production was however profitable.

Conclusively, the study investigated the effects of Sunshine Organic Fertilizer® rates on growth and yield of Yellow Passion Fruit. The study showed that Organic Fertiliser application affected growth, yield parameters and fruit yield of the crop.

1. Organic Fertiliser application improved the soil fertility with the change in soil physical and chemical constituents like the pH.
2. The application of Sunshine Organic Fertilizer® at 0.5 t/ha resulted in highest vegetative growth; yield components and cumulative fruit yield in low fertility soil in southwest Nigeria.
3. Application of the Organic Fertiliser at rates above 2.0 t/ha resulted in depressed vegetative growth of Yellow Passion Fruit at juvenile phase due to antagonistic interactions of the nutrients in the soil.
4. Total nutrient uptakes correlated significantly with the total dry weight..

5. Nitrogen uptake contributed more to the Total dry weight than any other nutrient

6. There was increased foliar nutrient concentration for most nutrients with the exception of Cu, Mg and Mn.

7. Organic Fertiliser application at 0.5 t/ha was found to be adequate to obtain optimum yield of Yellow Passion Fruit *(Passiflora edulis* var. flavicarpa DEGENER) in the first year of establishment in Siun, Ogun state, Nigeria.

Arising from the findings of this study it is suggested that application of Sunshine Organic Fertilizer® at 0.5 t/ha is adequate for the vegetative growth, reproductive development and yield of Yellow Passion Fruit on the field in Siun and Abeokuta area. Yellow Passion Fruit can be introduced into crop production system in rainforest-derived savannah zone of Nigeria. Its cultivation can be embarked upon in low nutrient status or impoverish soils with organic amendment for optimum growth and yield that ensures cash benefits.

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APPENDICES

Appendix 1: Effects of Organic Fertiliser application rates on Leaf area (LA cm^2) of Yellow Passion Fruit seedlings in the third experiment at Abeokuta in 2016

	Weeks after transplanting							
Organic Fertiliser (t/ha)	2	4	6	8	10	12	14	16
0	28.8	29.1	40	47.3	47.8	61.3	62.2	66.1
5.5	34.7	35.7	47.2	47.2	52.8	55	58.3	62.5
11.0	36.2	27.2	45.3	49.8	50	61.5	65.4	67.1
16.5	27.6	26.4	45.8	57.2	67.6	82.1	85.2	88.1
LSD (0.05)	Ns	Ns	Ns	ns	ns	26.59	25.21	24.31

LSD = Least significant difference
ns = not significant at $p \leq 0.05$

Note: Appendix 1 used for Figure 4.9

Appendix 2: Effects of Organic Fertiliser application on number of flower buds per plant of Yellow Passion Fruit under field condition at different weeks after transplanting

Organic Fertiliser (t/ha)	Weeks after transplanting											
	20	24	28	32	36	40	44	48	52	56	60	64
0	7^{b}	8^{b}	8^{b}	9^{b}	10^{b}	10^{b}	10^{b}	9^{b}	8^{b}	7^{b}	6^{b}	3^{b}
0.5	25^{a}	35^{a}	32^{a}	30^{a}	28^{a}	23^{ab}	17^{ab}	16^{ab}	13^{ab}	11^{ab}	10^{ab}	7^{ab}
1.5	23^{a}	31^{ab}	30^{ab}	28^{ab}	27^{ab}	21^{ab}	17^{ab}	24^{ab}	15^{ab}	13^{ab}	13^{ab}	8^{ab}
2.5	18^{ab}	16^{abc}	20^{ab}	18^{ab}	16^{ab}	18^{ab}	15^{ab}	14^{ab}	20^{a}	12^{ab}	14^{ab}	9^{ab}
SE	7.55	12.0	9.9	10.7	8.9	5.9	6.5	9.1	4.85	5.5	5.8	4.5

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Note: Appendix 2 used for Figure 4.10

Appendix 3: Effects of Organic Fertiliser application on number of flowers per plant of Yellow Passion Fruit under field condition

Organic Fertiliser (t/ha)	Weeks after transplanting 52	56	60	64
0	0^{b}	20^{b}	24^{b}	0^{b}
0.5	16^{ab}	74^{ab}	99^{ab}	21^{ab}
1.5	16^{ab}	106^{a}	117^{a}	53^{ab}
2.5	56^{a}	61^{ab}	69^{ab}	180^{a}
SE	3.75	9.11	8.8	7.10

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean
Note: Appendices 3 and 4 were combined and used for Figures 4.11 and 4.12

Appendix 4: Effects of Organic Fertiliser application on number of fruits per plant of Yellow Passion Fruit under field condition

	Weeks after transplanting					
Organic Fertiliser (t/ha)	60	64	68	72	76	80
0	0^{b}	0^{b}	0^{c}	0^{c}	0^{c}	0^{c}
0.5	12^{a}	46^{a}	46^{a}	5 0^{a}	54^{a}	72a
1.5	0^{b}	8^{b}	10^{b}	11^{ab}	14^{b}	14^{bc}
2.5	0^{b}	14^{b}	14^{b}	14^{b}	24^{ab}	28^{b}
SE	3.8	3.6	4.4	4.8	6.0	7.4

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error of mean

Note: Appendices 3 and 4 were combined and used for Figures 4.11 and 4.12

Appendix 5: Effects of Organic Fertiliser application on fruit yield per plant (g/plant) and cumulative fruit weight/plant (g) of Yellow Passion Fruit

Organic Fertiliser (t/ha)	Weeks after transplanting 60	64	68	72	76	80	Cumulative yield t/ha
0	0^{c}	0c	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}
0.5	238.7^{a}	112.3^{ab}	476.0^{a}	102.0^{a}	102.3^{a}	1031.3^{a}	1.21^{a}
1.5	87.0^{b}	239.0^{a}	63.0^{b}	91.0^{a}	112.7^{a}	592.0^{b}	0.660^{b}
2.5	81.0^{b}	216.0^{a}	180.0^{ab}	54.0^{ab}	63.0^{b}	594.0^{b}	0.660^{b}
SE	61.0	97.8	99.0	8.0	8.0	167.0	0.3848

Means in a column with same letters are not significantly different at $p \leq 0.05$
SE = Standard error

Note: Appendix 5 used for Figures 4.13 and 4.14