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THE EFFECT OF INDIGENOUS *ARBUSCULAR MYCORRHIZAL* FUNGI (AMF) ON PHYTO-ACCUMULATION IN *CARICA PAPAYA* HYBRIDS

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ABSTRACT

Papaya (*Carica papaya* L.) is a climacteric fruit with a resilient and distinctive aroma. The consumption of the fruit is global due to its high nutritive and medicinal values. However, there has been low production of quality papaya fruits due to unavailability of crucial mineral elements in the soils. The current study therefore, focuses on the effect of indigenous arbuscular mycorrhizal fungi (AMF) as a biofertilizer on the quality of papaya fruits. In order to verify AMF effectiveness on papaya fruits, four treatments were used: AMF inoculum only, composted farm yard manure (FYM) only, combination of AMF inoculum and compost FYM and control where only soil and sand media were used at a ratio of 1:1. Jomo Kenyatta University of Agriculture and Technology (JKUAT) and Malkia papaya hybrids were used. The papaya seeds from JKUAT and Malkia papaya hybrids were sown in trays and transplanted at 3 leaves stage into 5 litre pots within a green house. The AMF spores were bulked using sorghum plants to obtain the AMF inoculum. The treatments were added into the soil media of the papaya plantlets at a ratio of 1:3, every 4 weeks after first transplanting until they were 20 weeks old. They were then transplanted to 100 litre containers, where completely randomized design was used and replication of six papaya plants for each treatment and hybrid. Watering, weeding and cooling the green house with water fumes was carried out when necessary; as the papaya plants grew until the fruits attained physiological maturity. The fruits were separately harvested and ripened to a predetermined stage. They were then analysed for moisture content, crude fibre, minerals (nitrogen, phosphorous, potassium, magnesium, calcium, iron and zinc), ascorbic acid, total carotenoids and total polyphenols. Data obtained was subjected to two-way ANOVA at $p \leq 0.05$ significance level; means were separated using Tukey's HSD test in Genstat's 15th edition. JKUAT hybrid with AMF inoculum treatment had 3.07%crude fibre and 8.42mg/100g phosphorous content while JKUAT hybrid with both AMF inoculum and manure treatments had 4.9 % crude fibre and 9.88 mg/100g phosphorous content. Malkia and JKUAT hybrids with compost FYM treatment had potassium content of 98.31mg/100g and 109.4 mg/100g respectively while the controls had 31.58 mg/100g and 35.32mg/100g respectively. Incorporating soil media with manure and AMF inoculum improved the nutritive quality of papaya fruits and this was contingent on papaya hybrids.

Key words: biofertilizer, inoculum, mineral elements, nutritive quality, physiological maturity

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INTRODUCTION

Intake of vegetables and fruits on regular basis reduces risks of chronic ailments such as cataract, Alzheimer's disease, cancer, cardiovascular disease, stroke, among others [1]. Papaya displays a burst of respiration and ethylene production during ripening and hence, considered a climacteric fruit. The nutritional content of papaya fruits changes during the ripening stage and this is mostly due to carotenoids synthesis whose levels elevate during usual ripening [2]. Papaya fruit provides fibers as well as basic and complex sugars (fructose, glucose and sucrose). Degradation of crude fiber provides the commercially desired softness of the fruits' flesh while the sugar levels, which contribute to the sweetness of the fruit, vary during ripening process. Additionally, the fruit provides vitamin C which is continually synthesized as the fruits develop [3].

Naturally, plant roots interacts with soil organisms which can have either beneficial, neutral or pathogenic effects. Some of the beneficial organisms that have been recognized are *Arbuscular mycorrhizal* fungi (AMF) and they have an influence on the plants' community productivity, structure and diversity in a natural environment [4]. *Arbuscular mycorrhizal* fungi rely entirely on the carbon provided by the host plant and on the other hand, the plant obtains additional nutrients, protection against pathogens and enhanced water relations from AMF. Moreover, mycorrhizal association brings about accumulation of water in greater amounts to the host plants, particularly when water supply is limited and hence improved growth of plants [5].

The mechanisms by which AMF protects pathogen attack include enhanced nutrient status, alterations in root branching and root morphology, infection sites competition and the plant defense mechanisms becomes activated [6]. Mycorrhizal formation enhances exploration of greater volumes of soils and the absorption and translocation of nutrients to the plants due to the extraradical mycelium, hence the plants are able to take up more nutrients especially those with restricted mobility in soil, such as phosphorus as well as trace elements. Arbuscule, part of AMF, is the nutrient exchange site, finely branched and it penetrates through the root cell of the plants [7].

The symbiosis of AMF can also arouse the synthesis of secondary metabolites in plants which increases tolerance to biotic and abiotic stresses in plants and are helpful to the well-being of human health through their antioxidant activity [8]. *Arbuscular mycorrhizal* fungi can be applied alone or blended with the natural fields, so as to benefit the plants' overall growth and development directly or

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indirectly [9]. The roots of epiphytes, herbs, shrubs, aquatics, xerophytes, hydrophytes, trees, terrestrial and aquatics plants develop mycorrhizal associations when grown with the inadequate vital elements such as nitrogen, sulphur, zinc, copper, iron, phosphorus and boron [10].

Eradication of AMF communities leads to various challenges with plant establishment and existence [11]. This fungi can be eliminated through chemical or mechanical soil disturbance since the functioning and vigor of the AMF is reduced. Disturbance of the soil reduces the abundance of the spores and the colonization of roots especially to exotic AMF isolates that have not adjusted to soil environments as compared to indigenous isolates [11]. Consequently, isolation of indigenous AMF is a latent biotechnological means for plants' inoculation especially in disturbed ecosystems [12]. These beneficial effects of AMF have not been investigated on the nutritive quality of JKUAT and malkia papaya fruits and, therefore, the current research sought to improve the nutritive quality of these papaya fruits through isolation and inoculation of indigenous AMF into the soil media used for papaya establishment.

MATERIALS AND METHODS

Papaya treatments and establishment

The seeds of JKUAT and Malkia F1 hybrids were sown in sterilized mixture of soil and sand media at a ratio of 1:1. At 2 and 3 leaf stage, the seedlings were transplanted to 500g pots which contained sterilized soil media combined with treatments: AMF inoculum, composted FYM, and a combination of the AMF inoculum and the composted FYM at a ratio of 1:9. The control media comprised of sterilized soil media only. There were six replications of the plants from each hybrid and each treatment and routine cultural practices of the plants were carried out when necessary. The plantlets were transplanted to 2 litre pots 4 weeks after first transplanting and the treatments were added to the growing media every 4 weeks. When the seedlings were 20 weeks old, they were transplanted into 100 litre containers with three quarter full soil media and placed in a greenhouse. Routine cultural practices were carried out until the fruits were physiologically mature.

Determination of proximate composition

Determination of moisture content

Empty moisture dishes were weighed and recorded. Five grams of papaya fruit pulp was weighed and put into the dishes, dried into the oven at 105 °C for 4

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hours. The samples were then removed from the oven and cooled in a desiccator, weighed and recorded.

Determination of ash content

Crucibles were preconditioned in the oven, cooled in a desiccator and weighed. Approximately 5g of papaya fruit pulp was accurately weighed in triplicate into the weighed crucibles then charred using flame until all smoke was removed. The samples were then transferred into a muffle furnace and incinerated at 550 °C until white ash was obtained. The remains were cooled in a desiccator, weighed and recorded.

Crude fibre determination

About two grams of papaya fruit pulp was weighed into a conical flask. Approximately 200 ml of sulphuric acid (1.25% H_2SO_4) was poured into the flask and boiled for 30 minutes. The mixture was then filtered into another conical flask after which the residue was washed thoroughly with hot distilled water to wash away the acid. About 200 ml of 1.25% sodium hydroxide (NaOH) was added to the washed residue and the same process, above, repeated. The mixture was again filtered using glass wool and 15 ml of 1% hydrochloric acid (HCl) solution was used to rinse the residue followed by another rinsing with hot distilled water to rinse away the acid from residue. The residue was then washed using 10 ml petroleum ether in a fume hood. The residue was transferred to labelled crucibles and air-dried for 30 minutes. The residue in porcelain crucibles were then dried in a hot-air oven at 100°C for 1 hour before transferring to a desiccator to cool for 15 minutes. The crucible weight was recorded (W1). The crucibles were then incinerated in a muffle furnace at 550 °C for 3 hours. The crucibles and samples were then cooled in a desiccator and weighed (W2).

Crude protein determination

Approximately 2 g of the papaya fruit sample was weighed into a digestion flask together with a combined catalyst of 5 g of potassium sulphate (K_2SO_4), 0.5 g of copper sulphate ($CuSO_4$) and 15 mL of concentrated sulphuric acid (H_2SO_4). The mixture was digested in a fume hood until the color changed to blue-green. The contents were cooled and transferred into a 100 ml volumetric flask which was topped up to the mark using distilled water. A blank digestion composing of acid and catalyst was performed concurrently. Approximately 10 ml of the topped-up digest was added into a distilling flask and washed with 2 ml of distilled water. Fifteen milliliters of 40% sodium hydroxide (NaOH) was added and also washed with about 2 ml distilled water. Distillation was performed to obtain a distillate of

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about 60 ml in volume. Into the distillate, mixed indicator was added, followed by titration with 0.02N hydrochloric acid (HCl) until color changed to green.

Determination of crude fat and carbohydrate

Crude fat was determined using Soxhlet method. Extraction flasks were conditioned in the oven for 1 hour at 105 °C then cooled in a desiccator to room temperature and weighed. Five grams of pre-dried papaya fruit samples were weighed into extraction thimbles and covered with defatted cotton wool. The thimbles were placed in thimble support holders and fixed into the extraction unit. Fat extraction was done using petroleum ether and extraction proceeded for 8 hours. The extraction solvent was removed through rotary evaporation then the extracted fat was put to dry in an air oven at 105 °C for 30 min. The extraction flasks were cooled in a desiccator and the final weight of the flasks with the extracted fat taken. Carbohydrate content was determined by difference method.

Determination of ascorbic acid

Ascorbic acid content of the papaya fruit juice was determined by visual titration. Five milliliters of the juice was topped up with 10% trichloroacetic acid (TCA) in 100ml volumetric flask. The indicator (2, 6-dichlophenolindophenol) was titrated into 10ml of the fruit juice until pink color appeared.

Determination of selected minerals (Nitrogen (N), potassium (K), phosphorous (P), magnesium (Mg), iron (Fe), calcium (Ca) and zinc (Zn)

Five grams of the pulp was charred in the oven for 30 minutes then put in a muffle furnace at 550°C for eight hours to ash. The ash was allowed to cool and diluted with 10ml of 1N hydrochloric acid. The mixture was then filtered and diluted with 100ml of distilled water. Calcium, magnesium, zinc and iron were analysed using atomic absorption spectrophotometer, Potassium was analyzed using flame emission photometer, phosphorous was determined using spectrophotometer while nitrogen was determined using the same procedure for crude protein as described above (2.2.4).

Determination of total carotenoids

Total carotenoid content was determined by a modified chromatographic procedure. A sample of 5g of the papaya fruit was crushed in a pestle with a mortar. A spatula of hydroflorosupercel was then added and then extracted using 50ml cold acetone and filtered using glass funnel until the residue became white. Partitioning procedure followed using 25ml of petroleum ether in a separating funnel. Saponification was carried out by adding an equal amount of extract into 3ml of 10% (potassium hydroxide) KOH in methanol and a few drops of 0.1%

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butylatedhydrotoluene in petroleum ether. Sodium sulphate (anhydrous) was added to remove water and further concentration was carried out using a rotary evaporator.

Determination of total phenolic content

The total phenolic contents of the papaya fruit pulp were estimated using the Folin Ciocalteau reagent. The calibration curve was plotted using the absorbance results read after mixing 1 ml aliquots in the concentrations of 50, 100, 150, 200, 250, 300, 350, 400 and 450 mg/ml Gallic acid solutions with 5.0 ml of Folin Ciocalteu reagent (diluted tenfold) and 4.0 ml of sodium carbonate solution (75 g/l). The absorbance was measured after 30 minutes at 765 nm. For the fruit pulp, 1 ml was mixed separately with the same reagents, as performed for constructing the calibration curve. After 1 hr, the absorbance was measured to determine the total phenolic contents in both extracts separately.

RESULTS AND DISCUSSION

Minerals

In the current study, amending the soil media with AMF inoculum significantly ($p \leq 0.05$) affected the mineral contents of the papaya fruit. JKUAT hybrid with AMF inoculum treatment had phosphorous and potassium content of 8.42mg/100g and 109.4mg/100g respectively, as compared to compost FYM treatment which had 6.39 mg/100g and 98.31mg/100g respectively. Malkia hybrid with both AMF inoculum and compost FYM treatments had phosphorous and potassium content of 10.48mg/100g and 117.3mg/100g respectively as compared to compost FYM treatment which had 7.4mg/100g and 103.3mg/100g respectively. The calcium content in JKUAT hybrid with both AMF inoculum and compost FYM treatments was 19.45mg/100g while the controls had 8.21mg/100g. Iron content in Malkia hybrid with AMF inoculum was 0.4mg/100g while the control had 0.13mg/100g (Table 2). The mineral contents of the fruits was enhanced through AMF inoculation, as evidenced by Malkia and JKUAT papaya hybrids with AMF inoculum as compared to the controls and the media containing compost FYM only. Phosphorous, potassium, magnesium, calcium and iron contents greatly improved in the papaya fruits upon AMF inoculation into the soil media. *Arbuscular mycorrhizal* fungi has the ability to absorb nitrogen, potassium, phosphorous, sulphur, zinc and calcium from the soil and translocate it to related plants. This development is as a result of the increased absorptive surface area of the roots [13]. Oliveira *et al.* [14] observed that formation of AMF correlated with calcium, copper, iron and zinc in guarana (*Paullinia cupana*) and magnesium, calcium, copper and phosphorous in cupuacu (*Theobroma grandflorum*). Inoculating

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cucumber plant with *Glomus mosseae*, AMF species, brought about detection of elements such as zinc, copper and phosphorous which are essential for plant growth and this indicates that the fungal mycelium absorbed these elements for the plant [15]. Trindade *et al.* [16] also recorded increased absorption of potassium, copper and phosphorous in papaya seedlings after *Gigaspora margarita*, AMF species, was inoculated. Tomato fruits inoculated with AMF had increased levels of phosphorous, zinc and lycopene contents as compared to non- inoculated ones [17].

Ascorbic acid content

Ascorbic acid content was significantly ($p \leq 0.05$) different among the treatments. JKUAT hybrid with both AMF inoculum and compost FYM treatments had ascorbic acid content of 62.6 mg/100g while compost FYM treatment had 46.93mg/100g. Malkia hybrid with AMF inoculum and compost FYM treatments had ascorbic acid content of 68.32mg/100g while compost FYM treatment had 52.6 mg/100g (Table 3). Ascorbic acid contents increased in the papaya fruits of both JKUAT and Malkia hybrids through AMF inoculation in the current study. The controls had the least amounts of ascorbic acid contents in both hybrids. Higher concentration of ascorbic acid were observed on the fruits of inoculated strawberry plants. Accessibility of vitamin C biosynthesis substrates and also high levels of sugars particularly fructose and glucose in inoculated plants could lead to upsurge of ascorbic acid contents [18].

Total polyphenols contents

Soil amendment with AMF inoculum significantly ($p \leq 0.05$) affected the total polyphenols contents among the treatments. The total polyphenol contents in JKUAT hybrid with both AMF inoculum and compost FYM treatments was 58.56 mg GAE/100g while compost FYM treatment had 48.22mg GAE/100g and the control 42.8 mg GAE/100g. Malkia hybrid with AMF inoculum treatment had total polyphenol contents of 53.59 mg GAE/100g while fruits from compost FYM treatment 46.6 mg GAE/100g of total polyphenols. There were interactions between the hybrids.

Phenolic compounds accumulation (table 3) depends on the physiology of the fruit and these are the outcomes of the balance between biosynthesis and metabolic phases, for instance catabolism and turnover [19]. Phenols contribute to the taste and color of fruits and moreover, they possess antimutagenic and anticarcinogenic activities. The current study showed an increase of phenolic compounds after AMF inoculation and the total polyphenolic content of JKUAT and Malkia hybrids ranged between 42.62 mg GAE/100 g to 58.88 mg GAE/100 g. These results concurred

with total phenolic contents of six papaya cultivars studied by Farina *et al.* [20] which varied between 38.6 mg GAE/100 g and 60.2 mg GAE/100 g. Application of AMF in the soil media during transplanting increased the total phenolic compounds of the three studied cultivars of lettuce [21].

Proximates

The crude fibre content was significantly different (p≤0.05) among the treatments in JKUAT and Malkia papaya hybrids. JKUAT hybrid with both AMF and compost FYM treatments had 4.9% crude fibre and 1.35% in the treatment of compost FYM only. Malkia hybrid with AMF and compost FYM treatments had crude fibre of 5.7% and 2.0% in compost FYM only. Ash and oil contents were not significantly different (p≤0.05) among the treatments. Low ash contents in the fruit pulp shows that the total inorganic mineral content is also low [22]. The moisture content in control treatments on JKUAT hybrid was significantly different (p≤0.05) from other treatments with 89.6% moisture content. A fruit's moisture level affects its acceptability by the consumers as well as its consistency. Moisture retention was reported in okra fruits that were inoculated with mycorrhizal indicating a critical role of AMF in water relations in plants [23]. The plant moisture content in okra and pea cropping system remained high in mycorrhizal plants indicating the capability of inoculated plants to retain more moisture compared to non–inoculated plants [24].

The present study revealed high carbohydrates contents in non- inoculated treatments compared to inoculated ones. Carbohydrates (CHO) contents were also significantly different (p≤0.05) among the treatments. JKUAT hybrid with AMF and compost FYM treatments had the least amount of CHO (2.69%) while the controls had the highest amount of CHO (6.97%). Malkia hybrid with compost FYM treatment had the highest amount of CHO (7.98%) while Malkia hybrid with AMF and FYM manure treatment had the lowest amount of CHO (1.93%). There were interactions between the hybrids on CHO contents. Carbohydrates are necessary for the incorporation of ammonia in amino acids and accelerate proteins biosynthesis [25].

The proteins content in control treatments on Malkia hybrid was significantly different (p≤0.05) from other treatments with 0.11% protein content (Table 1). Low proteins levels were recorded in all the treatments. Elevated protein contents in plant leaves has been found to be associated with increased carbohydrate concentrations. The protein contents are as a result of amino acids that are used for the biosynthesis of protein after being incorporated by the plant [26]. Some fruits accumulate starch that breaks down into sugars during the ripening stage, through catabolic degradation, but this is an exception with papaya fruit [27].

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Total carotenoids content

Total carotenoids contents in the fruits were affected significantly ($p \leq 0.05$) by AMF inoculation in the soil media. Malkia hybrid with AMF inoculum treatment had total carotenoids contents of 3.4 mg/100g while the controls had 1.06mg/100g. JKUAT hybrid with both AMF inoculum and compost FYM treatments had the highest ($p \leq 0.05$) total carotenoid contents of 4.2mg/100g while the controls of both JKUAT and Malkia hybrids had the lowest ($p \leq 0.05$) carotenoids contents of 1.05mg/100g and 1.1 mg/100g respectively (Table 3). Carotenoids which are recognized include β-carotene, β-criptoxanthin and lycopene. Carotenoids and lycopene are among the pigments responsible for red and yellow tones produced after the chlorophyll degradation, and they increase as ripening progresses [28]. The present study showed that total carotenoids contents were enhanced through mycorrhization. The carotenoids contents of inoculated tomato, carrots and parsley fruits, increased significantly as compared to non-inoculated plants [29]. The final nutritional composition of climacteric fruits such as papaya is as a result of physiological and chemical changes that occur during pre and post-harvest periods. Total carotenoids contents in the flesh of papaya fruit increases during maturation stage [30].

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

Inoculating the seedlings with AMF tendered a crucial opportunity in formation of the symbiosis before transplanting. The plants survived the acclimatization associated with many seedlings and the overall performance was increased. *Arbuscular mycorrhizal* fungi (AMF) reduced application of fertilizers that have previously been considered crucial for effective growth of papaya fruits. Consequently, the high costs of fertilization and the environmental effects were eliminated. Moreover, the land ecosystems with unavailability of essential elements such as calcium, magnesium, phosphorous, potassium and zinc will be enhanced through AMF inoculation. The inoculation can be reckoned to be a good strategy to boost the symbiosis benefits and improve the fruits' nutritional status. The present study has verified the importance of AMF inoculation to papaya seedlings during transplanting and boosting the soil media with AMF inoculum for improved nutrients contents in papaya fruits for JKUAT and Malkia papaya hybrids. In addition, combining compost FYM and AMF inoculum resulted to better levels of the analyzed nutrients as compared to AMF inoculum only.

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Table 1: Effect of soil amendment on moisture (%), ash (%), proteins (%), crude fibre (%), oil (%) and carbohydrate (%) contents of JKUAT and Malkia F1 papaya fruits

Hybrid	Treatments	Moisture content	Ash	Proteins	Crude fibre	Oil content	CHO
Malkia	Control	90.0^{ab}	0.33^{a}	0.11^{a}	1.41^{f}	1.3^{a}	6.86^{ab}
	AMF	90.1^{ab}	0.43^{a}	0.076^{cd}	4.3^{c}	1.37^{a}	3.69^{c}
	AMF and Manure	90.6^{a}	0.35^{a}	0.09^{bc}	5.7^{a}	1.36^{a}	1.93^{c}
	Compost FYM	88.4^{b}	0.22^{a}	0.08^{bcd}	2.0^{e}	1.29^{a}	7.98^{a}
JKUAT	Control	90.19^{ab}	0.36^{a}	0.069^{d}	1.13^{g}	1.29^{a}	6.97^{ab}
	AMF	90.0^{ab}	0.84^{a}	0.077^{cd}	3.07^{d}	1.28^{a}	4.74^{bc}
	AMF and Manure	90.19^{ab}	0.83^{a}	0.097^{ab}	4.86^{b}	1.33^{a}	2.69^{c}
	Compost FYM	89.6^{ab}	0.5^{a}	0.071^{d}	1.35^{fg}	1.65^{a}	6.79^{ab}
	ANOVA (p - values)						
	Hybrids	0.431	0.11	<.001	<.001	0.606	0.658
	Treatments	0.018	0.546	<.001	<.001	0.680	<.001
	Hybrids × treatments	0.215	0.809	<.001	<.001	0.456	0.253

Means within each column followed by a different letter differ significantly at ($p \leq 0.05$) while means with a similar letter in a column do not differ significantly at ($p \leq 0.05$)

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Table 2: Effect of soil amendment on nitrogen (mg/100g), phosphorous (mg/100g), potassium (mg/100g), calcium (mg/100g), magnesium (mg/100g), iron (mg/100g) and zinc (mg/100g) contents of JKUAT and Malkia F1 papaya fruits

Hybrid	Treatments	Nitrogen	Phosphorous	Potassium	Calcium	Magnesium	Iron	Zinc
Malkia	Control	0.002^{d}	2.85^{f}	35.3^{f}	8.44^{f}	10.5^{f}	0.13^{d}	0.01^{e}
	AMF	0.012^{bc}	9.32^{b}	112.6^{b}	16.7^{c}	25.4^{cd}	0.42^{b}	0.06^{c}
	AMF and Manure	0.014^{ab}	10.5^{a}	117.3^{a}	18.5^{b}	27.6^{b}	0.51^{a}	0.09^{b}
	Compost FYM	0.013^{bc}	7.4^{d}	103.3^{d}	15.4^{e}	22.1^{e}	0.38^{bc}	0.04^{d}
JKUAT	Control	0.001^{d}	2.45^{f}	31.58^{g}	8.2^{f}	9.9^{f}	0.1^{d}	0.012^{e}
	AMF	0.012^{bc}	8.42^{c}	109.4^{c}	16.6^{cd}	27.3^{bc}	0.42^{b}	0.07^{bc}
	AMF and Manure	0.016^{a}	9.88^{b}	115.7^{a}	19.5^{a}	31.1^{a}	0.53^{a}	0.12^{a}
	Compost FYM	0.011^{c}	6.39^{e}	98.3^{e}	15.8^{de}	23.7^{de}	0.36^{c}	0.05^{cd}
	ANOVA(p-values)							
	Hybrids	0.445	<.001	<.001	0.075	<.001	0.192	<.001
	Treatments	<.001	<.001	<.001	<.001	<.001	<.001	<.001
	Hybrids × treatments	0.024	0.074	0.037	0.025	0.002	0.053	0.01

Means within each column followed by a different letter differ significantly at ($p \leq 0.05$) while means with a similar letter in a column do not differ significantly at ($p \leq 0.05$)

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Table 3: Ascorbic acid (mg/100g), total polyphenols (mg GAE/100g) and total carotenoids (mg/100g) of JKUAT and Malkia F1 papaya fruits

Hybrid	Treatments	Ascorbic acid	Total polyphenols	Total carotenoids
Malkia	Control	22.8^{f}	42.6^{e}	1.1^{f}
	AMF	58.1^{c}	53.6^{b}	3.4^{c}
	AMF and Manure	68.3^{a}	58.9^{a}	3.99^{ab}
	Compost FYM	52.6^{d}	46.6^{d}	2.35^{e}
JKUAT	Control	20.5^{f}	42.8^{e}	1.05^{f}
	AMF	54.6^{d}	51.2^{bc}	3.79^{b}
	AMF and Manure	62.6^{b}	58.6^{a}	4.2^{a}
	Compost FYM	46.9^{e}	48.2^{cd}	2.9^{d}
	ANOVA (p - values)			
	Hybrids	<.001	0.653	<.001
	Treatments	<.001	<.001	<.001
	Hybrids × treatments	0.005	0.087	<.001

Means within each column followed by a different letter differ significantly at ($p \leq 0.05$) while means with a similar letter in a column do not differ significantly at ($p \leq 0.05$)

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