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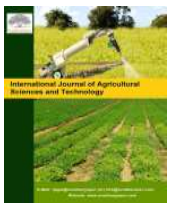

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Adaptation Trial of Improved Papaya (*Carica papaya* L.) Varieties in East Hararghe, Oromia, Ethiopia

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Abstract

Papaya *(Carica papaya L.)* is one of the most significant fruits in the Caricaceae family. The major papaya production constraints are the lack of improved papaya varieties and the low accessibility of the existing improved varieties in Ethiopia. Although East Hararghe is very suitable for papaya production, farmers' income generation from papaya production in the study area is still insufficient. Therefore, this study was conducted to identify adaptable, high-yielding, diseases, and pest-tolerant papaya varieties. A field experiment was conducted for four consecutive years (2019, 2020, 2021, and 2022) during the cropping season on the Boko research sub-site of the Fedis Agricultural Research Center. The treatments were arranged in a randomized complete block design with four replications. The treatments consisted of two improved papaya varieties (Braz-HIS and Meki-HLI) and one local check. The result of the study showed significant differences among varieties for all traits. Among the varieties, Meki-HL1 provided about 48.43% yield advantages as compared to local check. Therefore, for sustainability and to increase papaya production and productivity in the study area, the Meki-HL1 variety was recommended and needs to be demonstrated.

Keywords: *Adaptation, Fruit yield, Papaya, Varieties*

1. Introduction

Papaya (*Carica papaya* L.) is one of the most important fruits belonging to the family *Caricaceae*. It is the 4th most popular tropical fruit after bananas, mango, and pineapple (FAO, 2021). It originated on the Caribbean coast of Central America and is now cultivated throughout the tropical and subtropical regions of the world (FAO, 2021). Papaya is regarded as an excellent source of vitamin C (ascorbic acid), carotene, and riboflavin, as well as containing iron, calcium, thiamin, niacin, pantothenic acid, and vitamin B-6 (Saxholt *et al*., 2008). The edible portion of the fruit contains several minerals (sodium, potassium, calcium, magnesium, and phosphorus). Micro-minerals in papaya include iron, copper, zinc, manganese, and selenium (USDA, 2009). The ripe fruit may be consumed fresh, used for the extraction of papain (use as a meat tenderizer), and/or the green fruit is used by the health and cosmetic industries, among others. It could be used as a raw material for soft drinks, jams, and various preserves. The food canning industry could also use ripe fruits as fillers in the manufacture of many products (Josef, 2008).

Papaya gives yield year-round, regardless of season, as long as they get optimum agronomic management. There are two types: dioecious and hermaphrodites. In dioecious types, male and female flowers or inflorescences are born on

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different plants; whereas both flowers are found on a single tree in hermaphrodites or bisexuals (Agrawal, 2002). It grows best at an altitude of 1000–2000 m.a.s.l. with a mean temperature of 28-38°C. Temperatures higher than 36°C and lower than 16°C for extended periods will adversely affect the growth of the trees. Strong, cool, hot, and dry winds are not preferred (Saran and Choudhary, 2019). To ensure the successful establishment of a papaya plantation, it is better to use a shelterbelt with full sunshine (Saran and Choudhary, 2019). It grows and produces well on a wide variety of soils. The trees often develop a strong taproot shortly after planting. Well-drained sandy-loam soil with adequate organic matter is most important for papaya cultivation. It grows best in soils with pH values of 6.0–6.5 (Medina, 2003).

Papaya has been cultivated in several countries for local consumption and export markets. About sixty countries are producing papaya, most of them from developing countries. The world production of papaya was estimated at over 13.9 million tonnes of fruit in 2021. India, the Dominican Republic, Brazil, Mexico, and Indonesia were ranked the five largest papaya producers in that order (FAO, 2021). Ethiopia is the 4th largest papaya producer in Africa, next to Nigeria, the Democratic Republic of the Congo, and Kenya (FAO, 2021). Papaya ranks third in the amount of fruit production (623,814.8 quintals) from 4,428.1 hectares in the 2022 cropping season. It is being produced in all regional states of Ethiopia and consumed as fresh fruit in most parts of the country. About 717,659 Ethiopian smallholder farmers were involved in papaya production. The area of papaya production increased from 519,469.31 to 623,814.8 quintals from 2019 to 2022, which is a 20.08% total increment within four-year intervals (CSA, 2019; CSA, 2022).

Despite the crop being a high-value crop, the productivity of papaya in the country is 13.7 t ha^{-1} (CSA, 2022), which is very low when compared to the world average yield (30 t ha^{-1}) (FAO, 2021). In Ethiopia, the major papaya production constraints are the lack of improved papaya varieties and the low accessibility of the existing improved varieties with their improved agronomic practices. Particularly in East Hararghe, so far there have been no research efforts made in relation to adaptability studies for recently released improved papaya varieties. So in East Hararghe, the farmer uses only the local varieties with their traditional production methods. Even if the area is very suitable and the crop is very important commercially, farmers' income generation from papaya and productivity are still insufficient. Therefore, this study was conducted to identify adaptable, high-yielding, and diseases and pest-tolerant/resistant papaya varieties.

2. Materials and Methods

2.1. Experimental Site

The study was conducted at the Boko research sub-site of the Fedis Agricultural Research Center, East Hararghe Zone, in the 2019–2022 cropping season. The area is situated at a distance of about 24 km from Harar town in the southern direction. Fedis is located at the latitude of 09° 07'N and longitude of 042° 04'E, and an altitude of 1702 m.a.s.l., with a prevalence of lowlands. The soil of the experimental site is black with sand clay loam surface soil texture that contains 8.20% organic matter, 0.13% total nitrogen, available phosphorus of 4.99 ppm, soil exchangeable potassium of 1.68 cmol(+)/kg, and a pH value of 8.26. The mean rainfall has been about 801.3 mm for the last seven years. The mean maximum and minimum annual temperatures are 27.7 and 11.3°C, respectively, for the last seven years (FARC, 2022).

2.2. Experimental Design and Treatments

Two recently released papaya varieties (Braz-HIS and Meki-HL1**)** and one local check were used for the study. Both improved papaya varieties were obtained from the Melkassa Agricultural Research Center, and the local check was obtained from the farmer of the study area. All nursery preparations and subsequent management practices were applied according to the established procedure or recommendation. A seed was sown in polythene bags (10x15 cm) which were filled with the mixture of sandy loam virgin soil and sand at the ratio of 3:1. The distance between block, plot, row, and plant was 2.5 m x 2 m x 1.5m x 1.5m, respectively. The pits of 30 cm x 30 cm x 30 cm were dug out and filled with a mixture of 5 kg of FYM as a common dose for all the treatments. Seedlings of 45 days old were transplanted and the plots were kept free from weeds by regular hand weeding. The experiment was laid out in Randomized Complete Block Design with four replications. All other agronomic management practices were applied uniformly to all varieties as per the recommendation for the crop (MoA, 2016).

3. Data Collection and Analysis

All agronomic data, like plant height at first harvest, number of fruits per plant, fruit length, fruit diameter, fruit weight, and fruit yield, were recorded. All the collected data were subjected to analysis of variance using the R software version. Mean separation was done by using the least significant difference to compare significant treatment means at a 5% level of significance.

4. Results and Discussion

The combined analysis of variance showed that papaya varieties had significant differences for all traits (Table 1). This might be due to the genetic variance of the variety, which can show its different performance in a given area for all traits. Significant variation was reported by Wegayehu *et al*. (2016); Ayele *et al*. (2017), who found that the inherent characteristics of the varieties, space availability, nutrient availability, and weather conditions of the specific area influenced the performance of papaya varieties in terms of yield and yield components.

Table 1: Mean Squares from Combined Analyses of Variance Over Four Years (2019 to 2022) for Six Traits of Papaya Varieties

SV	DF	PH	NFPP	FD	FL	FW	FY
Replication	3	21.45	1.023	0.037	0.801	1089	7.93
Varieties	2	358.18**	390.111**	13.770**	20.110**	239855**	1439.82**
Error	6	25.09	7.14	0.042	0.258	1613	15.49
Total	11						

Note: *, **: significant at 5% and 1% respectively, SV = source of variation DF = degrees of freedom, PH (cm) plant height at first harvest, NFPP = number of fruit per plant, FL = fruit length, FD = fruit diameter, FW = fruit weight, FY = fruit yield. Means in each column followed by the same letter(s) were not significantly different at 5% significance level.

Table 2: Mean of Yield and Yield Component of Papaya Varieties Over Four Years (2019 to 2022)

Varieties	PH (cm)	NFPP	FL (cm)	FD (cm)	FW (g)	FY (t ha^{-1})
Meki-HL1	155.6[a]	70.86[a]	20.10[a]	10.727[a]	920.3[a]	67.30[a]
Braz-HS1	142.2[b]	66.30[a]	15.64[c]	7.143[c]	427.7[c]	29.49[c]
Local	137.4[b]	51.71[b]	17.30[b]	8.383[b]	612.3[b]	45.34[b]
LSD (5%)	12.09	7.386	1.321	0.51	99.6	10.82
CV (%)	3.7	5.2	3.3	2.6	6.7	10.1

Note: PH = plant height at first harvest, NFPP = number of fruit per plant, FL = fruit length, FD = fruit diameter, FW = fruit weight, FY = fruit yield. Means in each column followed by the same letter(s) were not significantly different at 5% significance level.

4.1. Plant Height and Number of Fruit per Plant

The maximum plant height and number of fruits per plant were recorded from the Meki-HL1 variety, and the minimum were recorded from Local and Braz-HS without significant differences among each other for plant height. There is no significant difference between Meki-HL1 and Braz-HS1 in terms of fruit production per plant (Table 2). This might be due to its genetic characteristics among those varieties. Similar findings were obtained by Gunnannavar *et al*. (2017), who found that plant height ranges from 112.23 to 146.15 cm and the number of fruits per plant ranges from 13.59 to 36.31. Kumar *et al*. (2015) found that plant height ranges from 120 to 185.33 cm.

4.2. Fruit Length, Fruit Diameter, and Fruit Weight

Significant maximums in fruit length, fruit diameter, and fruit weight were observed in the Meki-HL1 variety, whereas the Braz-HS1 variety exhibited the least in fruit length, fruit diameter, and fruit weight (Table 2). These results were in close confirmation with those obtained by Chalak *et al.* (2016). This indicates that the varieties fall into different fruit categories based on their fruit size, fruit diameter, and fruit weight, and they can be recommended for different purposes since fruit diameter, fruit length, and fruit weight are important traits for targeting specific markets that may demand either large or small fruit.

4.3. Fruit Yield

The most fruit was produced by the Meki-HL1 variety (67.30 t ha^{-1}), while the least fruit was produced by the Braz-HS1 variety (29.49 t ha^{-1}) (Table 2). Significant differences between kinds were discovered, indicating that the examined papaya varieties varied in their fruit yield. The current study's findings are in close agreement with those of Ayele *et al*. (2017), who noted variances in papaya fruit production in Braz-HS1 and Meki-HL1, ranging from 64.7 to 87.3 t ha-1, respectively. According to Fikre and Mensa (2021), the variation in papaya fruit output ranges from 49.31 to 91.3 t ha^{-1}.

5. Conclusion and Recommendation

As indicated in the result there were significant differences among the papaya varieties for all parameters. Among the varieties, Meki-HL1 provided about 48.43% yield advantages over the local check. Therefore, for sustainability and increased papaya production and productivity in the study area Meki-HL1 variety was recommended and needs to be demonstrated.

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