



Evaluation of Improved Papaya (*Carica papaya* L.) Varieties for Yield and Yield related Traits at Mechara, West Hararghe Zone

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Abstract

This study was conducted to identify adaptable and high yielding papaya variety(s) for West Hararghe Zone and similar agro ecologies. Three hermaphrodite papaya varieties along with local variety were evaluated for yield and yield related traits at Mechara Agricultural Research Center. The analysis of variance revealed the presence of significant differences among papaya varieties for most of evaluated traits. The single fruit weight of papaya varieties ranged from 264.2 to 867.5 g and the number of fruits per plant ranged from 8 to 24. The highest yield and yield related papaya traits like number of fruits per plant, single fruit weight, fruit length, and diameter were observed on Meki-HL1 variety. Papaya yield had positive and significant correlation with the number of fruits per plants, single fruit weight, fruit diameter, and length implying that selection of varieties based on the above traits is indirectly selection for high yielding variety. From this study, Meki-HL1 variety performed by all most important traits over the other varieties and it had 73.66% yield advantage over the local check. Therefore, Meki-HL1 variety was recommended for production in Mechara area and similar agro-ecologies.

Keywords: Adaptability; Fruit yield; Hermaphrodite papaya

Introduction

Papaya (*Carica papaya* L.) is an important fruit crop throughout the tropical and sub-tropical countries. It is native to tropical America and has become a very popular fruit worldwide due to its fast growth, high yield, long fruiting period, and high nutritive value. Papaya is cultivated for its fruits, consumed both fresh and as a processed product worldwide. A variety of products such as jam, jelly, nectars, ice cream, sherbet, yogurt, fruit leather, and dried slices may also be made from the ripe fruit. Unripe papaya makes a good concoction of vegetable stew, salad, or pickle. Papaya has been ranked one of the top nutritional scores among 38 common fruits. It is third most cultivated fruit in the world which occupies 15.36% of total tropical fruit production in the world [1].

Papaya is a polygamous species and it is difficult to identify a plant whether it is male, female, or hermaphrodite before flowering. The plants are male, hermaphrodite, or female. The male trees are uncommon, but sometimes occur when homeowners collect their seeds. Hermaphrodite trees (flowers with male and female parts) are the commercial standard, producing pear-shaped fruit. Papaya flowers can be grouped into three basic forms that reflect the whole plant gender: female, male, or bisexual (hermaphrodite). Broadly, there are two distinct types of *Carica papaya* plants: dioeciously and gynodioecious. Dioeciously papayas have male and female flowers on separate trees. Gynodioecious papayas bear female flowers on some trees and bisexual (hermaphrodite) flowers on others [2].

In Ethiopia, papaya is one of the most important fruit crops, which is produced for fresh and processed local consumption as well as for fresh fruit export purposes. Like for other fruits, the demand for papaya is increasing steadily due to rapid population growth and changes in dietary habits, but its production has not been expanded as the country's potential and market demand. In recent years, it has also attained great popularity primarily because of its easy cultivation, quick returns (early fruiting as compared to other fruit crops), adaptability to diverse soil and climatic conditions; it occupies significant positions in homestead, smallholder, and commercial production for home consumption and income generation [3].

Currently, more than 161 thousand hectares of land are under fruit crops, papaya took up 3.16% (5096 ha), of the fruit production. In Ethiopia, of the total national land allocated for Papaya production 29% is from the Oromia region. In Oromia, about 46843 hectares of land are under papaya production as west Hararghe contributed significantly (CSA, 2021). Despite the great potential for the production of papaya in Ethiopia including west Hararghe, the fruit industry has not been contributing much to the economy of the country. However, there is an increasing demand for papaya juice as an ingredient for blended juices, concentrates, syrups, juice drinks, and soft drinks [4].

West Hararghe, the fruit paradise, is one of the districts found in the Oromia regional state where different fruit crops are dominantly produced for income generation. However, the total area covered by papaya and its productivity is very low as compared to the potential that the region and West Hararghe have. Despite its importance and suitability to the agro-ecology of the country including the presence of suitable soil type, temperature, and rainfall for the production of papaya, Ethiopia's average papaya yield is 23.37 tons per hectare, which is very low compared to the crop potential, which rises to 31 ton/ha. One of the key factors contributing to the area's poor production, among other contributing factors is the shortage of improved cultivars that is appropriate for the environment and then the use of low-yielding cultivar. Fortunately, the outstanding hermaphrodite papaya variety has officially been released for production in Ethiopia. Therefore, these activities were conducted to evaluate the adaptability of improved

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papaya varieties and recommend the best-performing adapted variety for the target areas [5].

Materials and Methods

Description of the study area

The study was conducted at Mechara Agricultural Research Center on station for four-year consecutive years in the West Hararghe zone of Oromia National region, Eastern under rain fed condition. It is located at about 434 km away from Addis Ababa. McARC site is located between 8o.34' N latitude and 40.20' E longitude m.a.s.l. The altitude of the area is about 1760 m.a.s.l. It has a warm climate with annual mean maximum and minimum temperature is 31.8oc and 14oc, respectively. The mean annual rainfall is 1100mm. Daro lebu district is characterized mostly by flat and undulating land features and the rainfall is erratic; onset is unpredictable, its distribution and amount are also quite irregular. The soil of the experimental site is well-drained slightly acidic Nit sol.

Experimental materials

Three papaya varieties from the Melkasa Agricultural Research Center and One local seeds used farmers in Mechara area where used. Used as controls for this study. Seeds were placed in bed for germination, in a nursery site. After germination, the seedlings remained in the nursery for 60 days and then, they were acclimatized. At 75 days after germination, seedlings were planted in the field. The experiment was arranged in a randomized block design with four replications, spaced at 4 m x 6 m (4 m² plant⁻¹) between plants, in two rows, with six plants per plot (Table 1) [6].

Data collection and analysis

The following field data were collected; mean of plant height at first flowering date, days of first flowering, number of fruits per plant, fruit weight (g), fruit diameter (cm), fruit length (cm), number of fruits plant⁻¹, Yield per plants(Kg) and fruit yield (ton/he)throughout the years. The observations were made during the entire cropping season and the disease intensity was scored based on the level of symptoms present on the leaves and stems using the scale developed by. All the collected data were subjected to analysis of variance by using Genstat 18th edition. Mean separation was done by using Least Significant Difference (LSD) to compare significant treatment means at 5% level of significance.

Results and Discussion

The results of analysis of variance (ANOVA) showed the presence of significant ($P < 0.05$) and highly significant ($P \leq 0.01$) differences among the papaya varieties for most of traits, and yield of two harvesting cycle compiled results. Theirs presence of significant variations among papaya varieties for growth traits, and final for yields, This indicates the existence of substantial amount of variation among the varieties tested which confirms the possibility to select best variety. The significant variation among evaluated varieties to disease resistance might be because varieties were genetically diverse and it could be a good opportunity for breeders to select variety for resistance. Several researchers reported significant differences among papaya varieties studied (Table 2) [7].

Growth traits

Plant height at the first flowering date of papaya varieties ranged from 1.08 to 1.36 m with a mean height of 1.21 m while the first flowering date ranged from 9.5 to 14.2 months with an average of 11.2 months. From evaluated Varieties, Braz-HS1 varieties had early flowering than all varieties while local varieties had longer late flowering than all varieties. On the other hand, local varieties had significantly higher plant height at first flowering date than all varieties were as Braz-HS1 had shortest plant height at first flowering date [8]. The comparable results reported by with mean plant height at first flowering date of papaya varieties ranged from 50 to 97.7cm. The number of fruits per plants of papaya varieties ranged from 10 to 24 with an average of 18 fruits per plant. In this study, Braz-HS1 showed higher performance on fruit per plant for first year whereas Meki-HL1 variety had the highest number of fruits per plant than all varieties in the second harvesting cycle. The Variety with high number of fruits per plants is expected to give high yield.

Fruit and yield

From combined results, the fruit length of papaya varieties ranged from 12.51 to 21.6 cm with an average of 16.94 cm while fruit width ranged from 11.5 to 17.31 cm, with an average of 14.55 cm. Moreover, Meki-HL1 had higher fruit length and width than other papaya varieties and the local check whereas the Braz-HS1 papaya variety had the shortest fruit length and lowest fruit diameter than all evaluated varieties including local check. The weight of a single fruit ranged from 264.2 to 867.5 g with an average of 539.53 g while yield per plant

Table 1: Description of the Papaya varieties used for this study.

Varieties Name	Adaptation area	Year of Release	Released Center
Braz-HS1(CMF078-L56)	Central rift valley	2015	MARC
Koka-HM1(KK103-L446)	Central rift valley	2015	MARC
Meki-HL1(MK121-L516)	Central rift valley	2015	MARC
Farmers Variety(Local)	Mechara area	Local	-

Table 2: combined analyses of variance of Morpho-agronomic traits of Papaya varieties at Mechara during 2021-2023.

Source of Variations	Df	FD	FL	FNP	FW	YPP	Yield	DR
Varieties	3	203.5**	92.4**	343**	449290**	320.5**	916.8**	9.6**
Replication	3	20.4	3	117.6	50553	105.7	655.4	0.12
Error	21	23.08	5.4	41.8	47656	53.09	147.7	0.68
CV%	27	16.5	13.7	30.2	15.8	29.3	28.9	29

Noted: Df=degree of freedom, FD=Fruit diameter (cm), FL= Fruit length(cm), FNP= Number fruits per plants, FW= Fruit weight(g),YPP=Yield per plants(kg), Yield(ton/hectare),DR= Disease Reaction

ranged from 8.69 to 22.45 Kg with an average of 13.24 Kg. From the total evaluated Varieties, Meki-HL1 had significantly higher single fruit weight and yield per plant than all evaluated varieties. The observed considerable Meki-HL1 variety with significantly higher fruit length, width, and weight than other evaluated released varieties including local check suggested that this variety best than remains [9].

The mean yield of papaya varieties showed the highest range of variation, which ranged from 22.53 to 38.1 tons per hectare with an average of 28.4 ton per hectare in the first harvesting cycle and from 30.1 to 60.04 tons/hectare in the second harvesting cycle. From the combined results yield of evaluated varieties ranged from 26.32 to 49.06 tons/hectare with average of 33.4 ton/hectare and there is yield increments from the first to second harvesting cycle. On the other hand, Meki-HL1 had a significantly higher yield than all varieties whereas the lowest mean yield of papaya varieties was recorded from Koka-HM1 in both year including combined results. Meki-HL1 has 46.1%, 98.67%, and 73.66% yield advantage as compared to local check in first, second harvesting cycle, and combined result, respectively. Meki-HL1 variety has recommended for further production in the Mechara area and similar agro-ecologies. This study conformed with finding of who reported that fruit weight ranged from 432 to 923g, fruit length ranged 13.5 cm to 18.2 cm and Yield was ranged from 21.08 to 66.79 ton/ha. This study result also coincides with the finding reported that fruits weight was ranged from 289.89 to 927.80g; fruit length ranged 11.14cm to 22.61cm. The comparable results reported by with that fruit weight ranged from 401.9 to 711.6g, fruit length from 15.5cm to 18.25cm, fruit diameter ranged from 18.75 to 23.65cm (Table 3, Table 4 and Table 5) (Figure 1 and Figure 2).

Generally yield during first harvesting cycle was very low as

compared to that of second harvesting cycle; mean yield for second harvesting cycle showed 41.55% increment than mean yield of first harvesting cycle and Meki-HL1 varieties showed 57.59% significantly yield increments in second harvesting cycle.

Disease reaction of papaya varieties

The data pertaining to the field evaluation of four varieties against disease infection were summarized graph 3. During the period of study, the varieties showed varying degrees of disease severity on the leaves and stem [10]. The disease intensity of the varieties varied from 1.25 to 5.0. The varieties Meki-HL1 were found to have field tolerance disease with a disease intensity score of 1.62. The Koka-HM1 Variety, were found to be moderately susceptible, with an intensity score between 2.5 and local Variety, were found to be susceptible, with an intensity score 3.5. The Braz-HS1 Variety was found to be high susceptible category with an intensity score of 5.0 that showed extensive leaf distortion and plans died. In the present study, among the four varieties, none of them were found to be resistant to disease infection but the variety Meki-HL1 were found to have field tolerance (moderate resistance) to diseases (Figure 3).

Association among papaya traits

Papaya yield (ton/ha) had positively and high magnitude correlated with yield per plants, single fruit weight, fruit diameter and length. In addition, number of fruits per plants had positive correlation in medium magnitudes to yield. The positive association of traits due to the effect of genes can be the existence of strong coupling linkage between genes or the traits might be the results of pleiotropic genes that could control the traits in the same direction. This indicated the

Table 3: Mean values of yield and yield related parameters of Papaya varieties evaluated Mechara on station during 2019 - 2022/23(1st harvesting cycle).

Varieties	FFD	HFFD	NFPP	FD	FL	FW	YPP	Yield
Meki-HL1	10.8 ^{ab}	1.26 ^{ab}	20.48 ^{ab}	19.07 ^a	21.5 ^a	831.5 ^a	15.23 ^a	38.1 ^a
Koka-HM1	10.4 ^{ab}	1.075 ^b	15.72 ^{bc}	12.66 ^b	16 ^b	377.1 ^b	9.01 ^b	22.5 ^b
Braz-HS1	9.5 ^b	1.145 ^{ab}	24.27 ^a	11.48 ^b	12.5 ^c	264.2 ^b	10.71 ^{ab}	26.8 ^{ab}
Local	14.2 ^a	1.355 ^a	9.77 ^c	17.8 ^a	18.6 ^{ab}	589.5 ^{ab}	10.43 ^{ab}	26.1 ^{ab}
Mean	11.23	1.209	17.56	15.27	17.16	515.57	11.35	28.4
LSD at 5%	4.542	0.2354	6.408	2.85	3.457	446.45	5.355	13.39
CV (%)	25.3	12.2	22.8	11.7	12.6	54.1	20.5	29.5

Note: FFD=first flowering date, HFFD=height at first flowering date, NFPP=Number of fruit per plants, SFW=single fruit weight, FD=fruit diameter, FL=fruit length and YPP yield per single plants

Table 4: Mean values of yield and yield related parameters of Papaya varieties evaluated Mechara on station during 2019- 2022/23(2nd harvesting cycle).

Variety	FNPP	FD	FL	FW	YPP	Yield
Meki-HL1	27.8 ^a	15.54 ^a	21.67 ^a	903.5 ^a	29.66 ^a	60.04 ^a
Koka-HM1	6.68 ^b	11.75 ^b	14.88 ^b	412.5 ^b	8.37 ^b	30.1 ^b
Local	9.35 ^b	13.5 ^{ab}	13.37 ^b	398.4 ^b	9.27 ^b	30.44 ^b
Mean	15	13.6	16.64	571	15.8	40.2
LSD at 5%	16.4	3.15	2.231	149.8	13.25	14.06
CV (%)	34.5	13.4	7.7	15.2	29.8	20.2

Table 5: Combined mean values of yield and yield related parameters of Papaya varieties evaluated Mechara on station during 2021-2023.

Variety	NFPP	FD	FL	FW	YPP	Yield	Adva (%)
Meki-HL1	18.05 ^a	17.31 ^a	21.6 ^a	867.5 ^a	22.45 ^a	49.06 ^a	73.67%
Koka-HM1	9.74 ^b	12.21 ^b	15.43 ^{bc}	394.8 ^b	8.69 ^b	26.32 ^b	
Braz-HS1	24.27 ^a	11.5 ^b	12.51 ^c	264.2 ^b	10.71 ^b	26.79 ^b	
Local	7.51 ^b	15.7 ^a	15.99 ^b	494 ^b	9.85 ^b	28.25 ^b	
Mean	14	14.55	16.94	539.53	13.24	33.4	
LSD at 5%	6.73	2.5	2.42	226.99	7.58	12.64	
CV (%)	30.2	16.5	13.7	15.8	29.3	28.9	

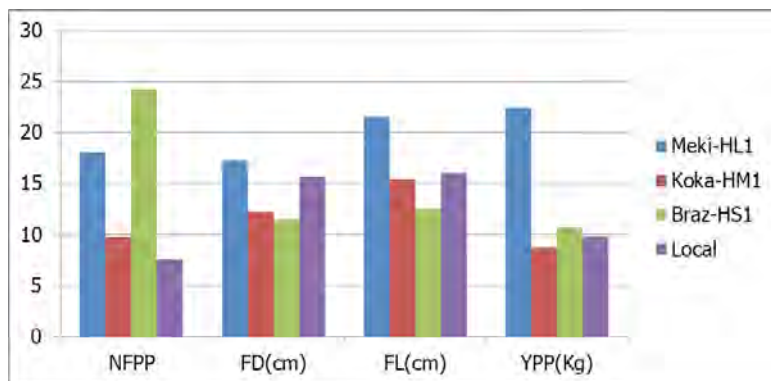


Figure 1: Combined mean value of NFPP (Number of fruits per plants), FD (fruit diameter), FL (fruit length), and YPP (Yield per plant) of papaya varieties during 2021-2023.

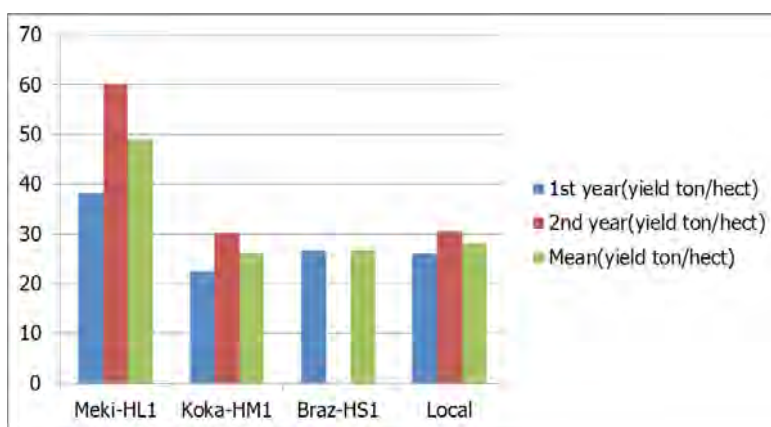


Figure 2: Mean yield value of papaya varieties evaluated at Mechara on station during 2021-2023 (mean of two harvesting cycle).

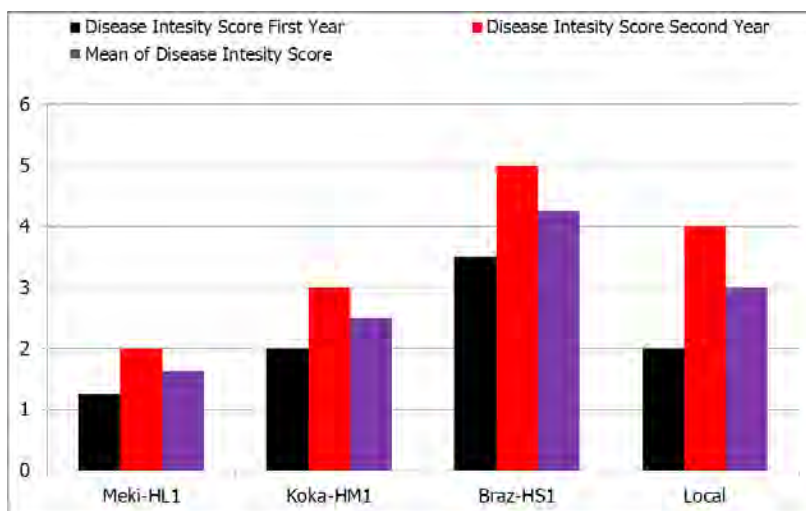


Figure 3: Disease intensity score of papaya Varieties evaluated at Mechara on station during 2021-2023.

Table 6: Association among papaya yield and traits.

Traits	Fruit Diameter	Fruit length	Fruit weight	Fruit per plants	Yield Per Plants	Yield
fruit diameter	*					
fruit length	0.884	*				
fruit weight	0.916	0.993	*			
Fruit per plants	-0.253	-0.137	-0.077	*		
Yield per plants	0.738	0.87	0.901	0.363	*	
Yield	0.794	0.926	0.947	0.243	0.99	*

papaya yield might increase if variety are selected for large fruit width and length, and higher single fruit weight. Therefore, Selection for a character based on its close association (positive and significant) with other characters is very useful for simultaneous improvement of all the associated characters [11].

Generally, in this study some traits had positively and significantly correlated, as well as other significant and negatively correlated with yield and among each other's. The association could be either genetic or environment or else the contribution of both factors. For positively associated traits, simultaneously improvement of one trait will improve the other. Whereas, those traits, which were negatively correlated the improvement for one trait antagonistically affect the other such association might be raise because of additive or non-additive gene action and the other factors such as pleiotropic that could control the traits within the same directio. In addition, the negative correlation might be because of different genes or pleiotropic genes that have dominance on the traits, which would control in different direction [12].

Conclusion and Recommendation

Using improved varieties of papaya could make an important contribution to increase agricultural production and productivity in areas like western Hararghe as Productivity of Papaya can be enhanced by selecting genetically improved varieties. Even though there are few papaya varieties released by different organizations in Ethiopia, there adaptability and yield performance under different environment is important for boosting papaya production and productivity in west Hararghe. In this study about three papaya varieties along with local variety were used to evaluate their adaptability at Mechara. From the combined analysis variety Meki-HL1 was the best for its single fruit weight, fruit diameter, fruit length, fruit number per plants and yield. More over Meki-HL1 variety has 73.66% yield advantage over local variety and more disease tolerant to disease. Most of the agronomic parameters were positively and significantly correlated with yield. Thus, Meki-HL1 variety was selected to be demonstrated on farmer's field for further scaling up.

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