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Adaptability evaluation of recently released hot pepper (*capsicum anum*) varieties at highland areas of west Hararghe, Ethiopia

Husen Yesuf Sirba, Temsgen Begna and Mastewal Gojam

Abstract
In Ethiopia, hot pepper [*Capsicum annum* (L)] is one of the leading vegetable crop: in terms of total production, the share of hot pepper is high as compared to other vegetables such as lettuce, tomatoes, head cabbage, onion. Likewise, West Harar ge highlands of study site is hot pepper potential area, and hot pepper is a major spice and vegetable crop which has been produced by the majority of farmers since now. However, its production is hampered by many biotic and abiotic factors specially lack of improved hot pepper variety suitable for the study area is the major challenge that affecting the productivity and production of hot pepper crop. Therefore, field experiment was conducted to evaluate adaptability of recently released hot pepper varieties. Treatments were consisted of three released hot pepper [*Capsicum annum* (L)] varieties (Melka awaze, Melka shote & Mareko fana) and arranged in a randomized complete block design (RCBD) with three replications. All the collected data were analyzed using R software (R 3.4.1). The combined analysis of variance showed that hot pepper varieties were significantly ($p \leq 0.05$) different from one another in number of primary branches per plant, significantly ($p \leq 0.01$) different in plant height, highly significantly ($p \leq 0.001$) different in days to 50% flowering, in days to 50% fruiting, in number of green fruits per plant, single green fruit weight, marketable green fruit yield, unmarketable green fruit yield and total green fruit yield. According to analysis of variance, the tallest plant height (62.33 cm), highest total green fruit weight (10.68kgplot^{-1}), marketable green fruit yield (18.04tha^{-1}) and total green fruit yield (19.07tha^{-1}) were recorded from variety Melka awaze. On the other hand, the longest (48) days to 50% flowering, highest number of primary branches per plant (11), days to 50% fruiting (75.33),number of green fruits per plant (97.67) and unmarketable green fruit yield (1.08tha^{-1}) were obtained from variety Melka shote. Thus, among hot pepper varieties evaluated, variety Melka awaze was superior in total green fruit weight, marketable green fruit yield and total green fruit yield. Hence, variety Melka awaze caused extra 16.76%, 17.12% & 15.05% total green fruit weight, marketable green fruit yield and total green fruit yield respectively as compared to hot pepper varieties with lowest result of these parameters. Therefore, as variety Melka awaze is superior over the rest varieties in these parameters, could be recommended for study areas to maximize productivity and production of hot pepper.

Keywords: Total green fruit weight, extra marketable green fruit yield, released hot pepper varieties

1. Introduction
The hot pepper [*Capsicum annuum* (L.)] crop is belonging to the genus *Capsicum* and family *Solanaceae* Rodriguez *et al*. (2008). According to Terry and Subodh (2005) [28], the genus *Capsicum* consists of about 20 species and only four species are under cultivation, out of which *Capsicum pendulum* and *Capsicum* pubescens are restricted to South and Central America, and other two species such as *Capsicum annuum* and *Capsicum frutescent* are commonly cultivated throughout the world, and among the cultivated species, the cultivation of *Capsicum annuum* L. is the most widely spread all over the world. Moreover, as mentioned by Boland (1992) [5], despite their vast trait differences most cultivars of peppers commercially cultivated in the world belongs to the species *Capsicum baccatum* Purse love *et al*. (1981) [25] reported that the origin of *Capsicum Sp*ecies is extended from Mexico in the North to Bolivia in the South of Latin America, where it has been part of the human diet since about 7500 BC.
Hot pepper [*Capsicum annuum* (L.)] is considered as vegetable and spice crop and grown extensively under various environmental and climatic conditions. Similarly, hot pepper is an important cash crop for smallholder farmers in developing countries such as Ethiopia, Niger

Ghana, China, India, Pakistan, Bhutan, Indonesia, Cambodia, and Thailand (Khan and Raj, 2006) [20]. According to the report of Ahmed *et al*. (2000) [2], India is the largest producer of chilli in the world. Due to its high cash value and consumption rate, the annual trade of chilli is approximately 17% of the total spice trade in the world (MARC, 2004) [22].

According to the report of FAOSTAT (2017) [12], in Ethiopia, in terms of total production, the share of pepper is high as compared to other vegetables such as lettuce, tomatoes, head cabbage, onion, and others (FAOSTAT, 2017) [12]. Hot pepper is one of the most important vegetable crops in the world. Regarding production status of hot pepper in the country, FAOSTAT (2018) [13] reported that in Ethiopia, in 2018 cropping season, the total cultivated area under pepper was 8001 hectare with a production quantity of 4889 tons. Also, the productivity of the crop in Ethiopia is 6.11 tha^{-1} (FAOSTAT, 2018) [13].Based on the report of USAID (2013) [30], the national average yields of hot pepper are 6.3 t ha^{-1} for green pod and 1.8 tha^{-1} for the dry pod, which is far below the dry pod yield (2.5-3.7 tha^{-1}) of improved varieties at research fields of Ethiopia and world average yield of 3 to 4 tha^{-1}.In Ethiopia, three major hot pepper producing regions recognized. As reported by Ethiopian export promotion agency (EEPA) (2003) [11] the major hot pepper producing regions in Ethiopia are Amhara, Southern Nations and Nationality People's Regional State and Oromia pepper generated an income of 122.80 million Birr for farmers in 2000/2001, and this value further jumped to 509.44 million Birr for smallholder farmers in 2004/2005.

Hot pepper is a multipurpose crop, used as a vegetable and spice, and also it is source of income for Ethiopian smallholder farmers. As mentioned by Assefa *et al*., 2020) [3], the hot pepper is an important food and cash crop in Eastern and Central Africa including Ethiopia playing a major role in national food security and nutrition, poverty alleviation and income generation, and; provides employment opportunity in the production, processing and marketing sub-sectors. Hot pepper is in the daily diet of most Ethiopians, and fruits are consumed as fresh, dried, or processed products, like vegetables, as spices or condiments (Assefa *et al*., 2020) [3] and similar idea was reported by Acquaah (2004) [1]. Nowadays, it is produced in many parts of the country because, for most Ethiopians food is tasteless without hot pepper. Because it is the main parts of the daily diet of most Ethiopian societies. The fine powdered pungent product is an indispensable flavoring and coloring ingredient in the common traditional sauce "Wot", whereas the green pod is consumed as a vegetable with other food item (Melaku *et al*., 2015) [23]. According to the report of CSA (2018) [8], The average daily consumption of hot pepper by Ethiopian adults is estimated 15 gm, which is higher than tomatoes and most other vegetables.

As identified by many researchers in Ethiopia, several factors limiting the productivity of hot pepper: the major ones are lack of stable well-adapted varieties, lack of knowledge in using optimum nutrient supply in every area of production zone, an insufficient supply of disease and insect pests' tolerant varieties (Assefa *et al*., 2020). [3] Similarly, Similarly, the major reasons associated with yield reduction in Ethiopia are shortage of improved varieties, infestation of disease and pests, poor agronomic practices, poor post-harvest handling.

According to Fekadu and Dendena (2006) [14], despite its importance, Ethiopian hot pepper production has been hampered by a number of factors, including the use of inferior varieties, poor cultural practices, and the increasing prevalence of fungal, bacterial, and viral diseases. CSA (2006) [7] reported that in spite of its importance, the hot pepper production system for green and dry pod has stayed as low input and low output with a national average yield of 7.6 t/ha for green pod whereas it was 1.6 t/ha for the dry pod respectively. Fekadu and Dandena (2006) [14] also expressed that the decline of hot pepper production is also attributed to poor varieties, poor cultural practices, the prevalence of fungal (blights) and bacterial as well as viral diseases. Likewise, West Haraghe highlands of study site is potential area for hot pepper production. As mentioned by Kinde and Asfaw (2016) [21], in West Hararghe highlands hot pepper is a major spice and vegetable crop which has been produced by the majority of farmers. However, its production is hampered by many biotic and abiotic factors specially lack of improved hot pepper variety suitable for the study area is the major challenge that affecting the productivity and production of hot pepper crop. Therefore, objective of the experiment was to evaluate adaptability of recently released hot pepper varieties for the study area of the West Hararge highlands.

2. Materials and Method

2.1. Experimental Area Description

Field experiment was conducted from 2018 - 2020 cropping seasons at highland areas of West Hararge. West Hararghe Zone is located at 8 ° 39' 59.99" N latitude and 40 ° 29' 59.99" E longitudes (Nigus *et al.,* 2022) [24]. Moreover, this Zone is subdivided into three major climatic Zones namely highland locally known as Dega (12.49%), midland known as Woinadega (38%) and lowland locally known as Kola (49.5%). The topography of west Hararghe is characterized by steep slopes in the highlands and mid-plains in the lowland areas. Mean monthly temperature range of west Hararghe is from 20.5-24 ºC (Nigus *et al.,* 2022). Similarly, the rainfall of west Hararghe is dispersed and the year is classified in to two rainy seasons, Belg from February to April and Meher or the main season rainfall from June to September with small showers in dry months. The average annual rainfall is ranged from 600-2000 mm for higher elevations of Woinadega and Dega areas, and altitude of west Hararghe is ranged from 1200-3600 m.a.s.l. (Nigus *et al.,* 2022) [24].

2.2. Treatments and Experimental Procedures

Field experiment was conducted from 2018 - 2020 cropping seasonsto evaluate adaptability of recently released hot pepper [*Capsicum annum* (L.)] varieties. Hence, treatments composed of three released hot pepper varieties (Melka awaze, Melka shote & Mareko fana) arranged in a randomized complete block design (RCBD) with three replications. Details about hot pepper varieties presented in the (Table 1).

Table 1: Descriptions about hot pepper [*Capsicum annum* (L.)] varieties evaluated

Name of varieties	Year of release	Maturity (Days)	Dry fruit yield (tha^{1})	Altitude (m.a.s.l)	Rain Fall(mm)	Temperature (0C)
Melka awaze	2007	100-110	2.5-2.8	1200-2200	900-1300	18/29
Melka shote	2007	110-120	2.0-3.0	1000-2200	900-1300	15//27
Mareko fana	1984	110-130	1.5-2.0	1400-2200	600-1337	20/29

Source: (Kahsay Yemane, 2017) [19]

2.3. Land preparation, Sowing and Transplanting

After the nursery area had been preparation, three level seed beds of 5 m x 1 m (5 m^2) sized were prepared for three hot pepper varieties separately. Before sowing, soil of each seed beds was top dressed with100 g NPS fertilizer to improve the nutrient content of the soil of beds. After top dressing of the soil of each seedbed with NPS fertilizer, hot pepper seeds were sown in rows at 15 cm apart between rows and covered with light soil and then seed beds were mulched with 3 cm thick dry grass.

After sowing and mulching, seed beds were watered properly using watering can and also watering operation was done every day and continued until the hot peeper seeds get germinated and then done every two days and twice in a week interval. Accordingly, to get vigor seedlings, other relevant nursery activities such as weeding, hoeing, thinning and shade construction were done. Before transplanting, experimental field was well tilled, leveled and divided into three blocks and nine (9) individual plots of 4 m x 2.8 m (11.2 m^2) sized to accommodate 4 rows of 70 cm apart to contain 13 and 53 plants per row and per plot respectively. When hot pepper seedlings attained transplanting height of 15-25 cm, carefully uprooted and transplanted to the well-prepared experimental plots at 70 cm and 30 cm inter-row and intra-row spacing respectively. As far as fertilizer application is concerned, 200 $kgha^{-1}$ NPS and 100 $kgha^{-1}$ Urea were used: 150 kg NPS was applied at transplanting, 25 kg NPS & 50 kg Urea were applied after 15 days of transplanting and the remaining 25 kg h NPS & 50 kg Urea were applied after 45 days of transplanting.

2.4. Data Collection

2.4.1. Growth and Phonological Parameters of Hot Pepper [*Capsicum annum* (L.)]

Under these parameters, collected data were consisted of days to 5% flowering, number of primary branches and plant height. Days to 50% flowering was recorded and determined by counting the number of days from date of transplanting up to the days when 50% of the plants get flowered and used for analysis. The number of days where 50% of the plants started flowering beginning from the days of transplanting was used to measure days to 50% flowering. Number of primary branches per plant were determined based on the primary branches of ten randomly selected plants from net plot area taken at the maturity stage and their average values were used for analysis. Plant height was determined by measuring the heights of ten randomly selected ten plants from the ground level to the apex from net plot area using rules at maturity stage and mean values were used for analysis.

2.4.2. Yield and Yield Component Parameters of Hot Pepper [*Capsicum annum* (L.)]

Collected data under this parameter composed of days to 50% fruiting, number of green fruits per plant, single green fruit weight, marketable green fruit yield, unmarketable green fruit yield and total green fruit yield. Hence, Days to 50% fruiting was recorded and determined by counting the number of days from date of transplanting up to the days when 50% of plants get fruited. Numbers of physiologically matured green fruits per plant were recorded from ten randomly selected sample plants per plot from middle rows of each experimental plot and then average values in g per plant were used for analysis. Total green fruit weight per plot was determined from fruits often randomly selected samples plants from middle rows per plot harvested and weighted using sensitive balance and their average fruit weight per plant was multiplied by the total number of plants from net plot area of each experimental plots and then their product was considered as total green fruit weight per plot used for analysis. Single physiologically matured green fruit weight was calculated from fruits of ten random sample plants that is total green fruit weight of sample plants in gram divided by the total number of fruits harvested were used as an average single green fruit weight and then taken for analysis.

Marketable green fruit yield (tha^{-1}) was determined by taking entire green fruits free from any form of defect and visible damages taken from net plot area of each experimental plots considered as marketable fruit yield and then weighed using sensitive balance in kg and converted in to ton basis per hectare. Unmarketable green fruit yield (tha^{-1}) was determined by considering small sized, discolored, rotten, infected, pest attacked and those fruits lacked uniformity recorded from net plot area of each experimental plot were taken as unmarketable fruit yield and weighed using sensitive balance in kg and converted in to ton basis per hectare. Similarly, total green fruit yield (tha^{-1}) was determined from entire matured fruits from middle two rows of net plot area of each experimental plot were considered as total green fruit yield and then weighed using sensitive balance in kg and converted in to ton basis per hectare. Moreover, total fruit yield (tha^{-1}) was also determined by adding marketable and unmarketable fruit yield

2.5. Data Analysis

All the hot pepper parameter data collected were subjected to analysis of variance using R software (R 3.4.1). Means that differ significantly were separated using the least significant difference (LSD) procedure at 5% probability level of significance

3. Results and Discussion

3.1. Growth and Phonological Parameters of Hot Pepper [*Capsicum annum* (L.)]

3.1.1. Days to 50% Flowering

According to combined analysis of variance, hot pepper varieties were significantly varied at $p \leq 0.001$ probability level in days to 50% flowering (Table 2). It is in line with finding of Melaku *et al*. (2015) [23] who revealed that the number of days to 50% flowering showed highly significant. Delelegn *et al*. (2014) [10] reported that hot pepper varieties were highly significant different for days to 50% flowering in Jim ma and Seka-chekorsa areas. But it is in disagreement with the finding of Cherne *et al*. (2019) [6] who explained that days to 50% flowering showed non-significant differences among the hot pepper varieties.

According to analysis of variance, hot pepper varietiesattained50%flowering in different day lengths (Table 2).Variety Mareko fana attained its 50% flowering in 41.33 days, Melka awaze 43 days and Melka shote in 48 days (Table 1). Thus, variety Melka shote attained its 50% flowering in longest (48) days however, variety Marko fan attained its 50% flowering in shortest (41.33) days. In agreement with the finding of Kahsay Yemane (2017) [19] who showed that Melka Shote took longer days to flower while Mareko fana flowered earlier. Differences among hot pepper varieties in days to50% flowering might be because of genotypic variability among them and also due environmental influences on them.

Never the less, variety Mareko fana and Melka awaze were not statistically different from each other in days to 50% flowering. The range between longest and shortest days to 50% flowering was 7 days. This is indicating that variety Melka shote needs additional 7 days to attain its 50% flowering as compared to

variety Mareko fana. Hence, variety Melka shote is late flowering type as compared to Mareko fana followed by Melka Awaze. Variations among hot pepper varieties in relation to days to 50% flowering could be due to genetic makeup differences among them. In line with the finding of Melaku *et al*. (2015) [23] who reported that the variation in the days to 50% could be probably due to their genetic factor.

3.1.2. Number of Primary Branches per Plant

Hot pepper varieties were significantly differed from one another at $p \leq 0.05$ probability level in number of primary branches per plant (Table2).It is disagreed with the finding of Melaku *et al*. (2015) [23] who showed that no significant difference was observed on branch number of different pepper varieties. The analysis results of number of primary branches per plant (7, 7.67 and 11) were statistically dissimilar and were in range of 7 - 11 per plant.

Variety Mareko fana was caused (7) primary branches per plant, Melka awaze (7.67) and Melka shote (11) branches per plant (Table 2).This shows that the highest (11) number of primary branches per plant was obtained from variety Melka shote while the lowest (7) was obtained from variety Mareko fana. The range between highest and lowest number of primary branches per plant was4. However, variety Mareko fana and Melka awaze were statistically at par in number of primary branches.

3.1.3. Plant Height

Based on the combined analysis of variance, hot pepper varieties were significantly differed at $p \leq 0.01$ probability level in relation to plant height (Table 2). This result in line with the report of Gebremeskel *et al*. (2015) [15] who found that there was significant differences among three varieties evaluated for two years in Raya valley, Northern Ethiopia for plant height. However, disagreed with the finding of Melaku *et al*. (2015) [23] who showed that no significant difference was observed on plant height of different pepper varieties.

Due to varietal difference effect, plant height results (48.73 cm, 57.03 cm & 62.33 cm) were statistically different and ranged between 48.73 cm - 62.33 cm. accordingly, the plant height (48.73 cm) was obtained from variety Melka shote, 57.03 cm from variety Mareko fana and 62.33 cmfrom variety Melka awaze. Thus, the tallest (62.33 cm) plant height was recorded from variety Melka awaze whereas the shortest (48.73 cm) was obtained from variety Melka shote (Table 2).Difference in plant height between variety Melka awaze and Melka shote was about 13.6 cm. An increment in plant height in percent basis with variety Melka awaze over Melka shote was 21.82%.Hence, this is showing that variety Melka awaze was tallest, variety Mareko fan a an intermediate and variety Melka shote was shortest. Another thing is regarding variation in plant height among hot pepper varieties might be due to genetic potential variability among them.

Table 2: Combined mean of days to 50% flowering, number of primary branches per plant and plant height of hot pepper

Variety treatments	Days to 50% Flowering	Number of Primary Branches per Plant	Plant Height (cm)
Melka awaze	43b	7.67^{b}	62.33^{a}
Melka shote	48^{a}	11.00^{a}	48.73^{c}
Mareko fana	41.33^{b}	7.00^{b}	57.03^{b}
LSD (0.05)	2.20	3.02	4.88
CV%	8.20	15.58	9.84
Significant level	***	*	**

3.2. Fruit Yield and Fruit Yield Components of Hot Pepper [*Capsicum annum* (L.)]

3.2.1. Days to 50% Fruiting

The combined analysis of variance showed that days to 50% fruiting results were statistically differed from one another at $p \leq 0.001$ level of probability (Table 3). In agreement with the finding of Cherne and Zibelo (2019) [6] who reported that hot pepper varieties evaluated showed significant difference for days to 50% fruiting. However, in disagreement with the finding of Cherne *et al*. (2019) [6] who reported that days to 50% fruiting showed non-significant differences among the hot pepper varieties.

Days to 50% fruiting results (65.67, 68 & 75.33 days) were ranged between 65.67- 75.33 days (Table 3). Due to variety difference effect, days to 50% fruiting results were dissimilar: variety Melka shote attained its50% fruit in gin 75.33 days, variety Melka awaze in 68 days and Mareko fanain 65.67 days. Hence, with this result, the longest (75.33) days to 50% fruiting observed from variety Melka shote whereas the shortest (65.67) days to 50% fruiting caused by variety Mareko fana. The difference between the highest and lowest days to 50% fruiting was about 10 days. This is to show that variety Melka shote was late fruiting, variety Melka awaze intermediate and Mareko fana was early fruiting type. In general, variations in day's to50% fruiting among hot pepper varieties might be due to combined effect of genotype and environmental factors.

3.2.2. Number of Green Fruits per Plant

Hot pepper varieties showed significant ($P \leq 0.01$) difference for number of green fruits per plant (Table 3). In line with the finding of Melaku *et al*. (2015) [23] who reported that pepper varieties were significantly different at $p \leq 0.001$ probability level in relation to number of fruits per plant. According to the finding of Kahsay Yemane (2017) [19], there was a significant difference in fruit number per plant of the varieties. This is agreed with the report of Delelegn *et al*. (2014) [10] who mentioned that hot pepper varieties were highly significant different for number of fruits per plant in Jimma and Seka-chekorsa.

Number of green fruits per plant results (52.67, 57.00. 97.67) were ranged from 52.67-97.67 per plant. Due to genotypic variability among hot pepper varieties, number of green fruits per plant results were statistically dissimilar. Variety Melka awaze caused the number of green fruits per plant of 52.67, Mareko fana (57.00) and variety Melka shote (97.67) per plant. The highest (97.67) number of green fruit per plant was recorded from variety Melka shote while lowest (52.67) was obtained from variety Melka awaze. But on the contrary with the finding of Cherne *et al*. (2019) [6] who revealed that the highest number of green pod yield per plant was obtained from Mareko fan a (608.7). A hot pepper variety with the highest number of green fruit per plant could be due to having more number of branches enabling the formation of more number of fruits per plant. On the other hand, variations among hot pepper varieties in number of green fruits per plant could be because of genetic potential difference among them and effect of environment on growth and development of the crop.

3.2.3. Total Green Fruit Weight (kg plot^{-1})

Hot pepper varieties were significantly ($p \leq 0.001$) differed from one another in total fruit weight per plot (Table 3). The analysis results of total green fruit weight (8.89 kg, 9.63 kg & 10.68 kg per plot) were statistically differed from one another and ranged between 8.89 – 10.68 kg per plot**.**

Because of varietal difference effect**,** total fruit weight values per plot were differed significantly. Different sized fruits per plot were recorded: variety Melka shote caused the total green fruit weight of 8.89 kg per plot, variety Mareko fana (9.63 kgplot^{-1}) and Melka awaze (10.68 kg plot^{-1}). With this, the largest (10.68 kg) total green fruit weight per plot was recorded from variety Melka awaze while smallest (8.89 kg)per plot obtained from variety Melka shote, whereas variety Mareko fana was an intermediate in total green fruit weight per plot. Moreover, the range between the highest and the smallest total green fruit weight per plot was 1.79kgha^{-1}, which is an increment in total green fruit weight due to effect of variety Melka awaze over variety Melka shote, Again, this difference in percent basis was 16.76% due to effect of variety Melka awaze as compared to variety Melka shote.

3.2.4. Single Green Fruit Weight (g fruit^{-1})

According to analysis of variance hot pepper varieties were significantly differed at $p \leq 0.001$ probability level in relation to single green fruit weight (Table 3). Due to varietal difference effect, single green fruit weight results (3.96g,5.96g and 7.98g) per fruit were statistically dissimilar and ranged between 3.96 - 7.98 g per fruit.With this result, variety Melka shote was caused single green fruit weight of (3.96 g fruit^{-1}), Melka awaze (5.96 g fruit^{-1}) and Mareko fana (7.96 g fruit^{-1}).

This is showing that the largest (7.98 g fruit^{-1}) single green fruit was obtained from variety Mareko fana. But the smallest (3.96 g fruit^{-1})was obtained from variety Melka shote(Table 3).This lowest result with Melka shote variety is in agreement with the finding of Kahsay Yemane (2017) [19] who showed that the lowest single fruit weight per fruit was obtained from variety Melka shote. Cherne *et al*. (2019) [6] also reported that variety Mareko fana produced the largest fruit size (7.3 g) while Melka shote had the least pod weight (4.5 g).

The range between the largest and the smallest single green fruit weight was 4.02 g fruit^{-1}. With this, variety Mareko fana caused extra 50.38% single green fruit weight as compared to variety Melka shote. On the other hand, the lowest single fruit weight per fruit with variety Melka shote might be due to cumulative effect of genotype and environmental factors. This idea is also agreed with the report of Kahsay Yemane (2017) [19] who revealed that the lowest fruit weight with variety Melka shote affected by both genotype and environment.

In addition, large sized green fruits are likely to be more accepted by the consumers as well as in the markets. This idea is in agreement with the report of Beyene and David (2007) [4] who revealed that hot peppers with larger pod sizes are appreciated for their quality, and fresh and dried pods are in high demand in Ethiopian markets. As fruit weight has direct effect on fruit yield, affected by genotype and environmental factors. This is in line with report of Seleshi *et al*. (2014) [27] who mentioned that both genotype and environment influence fruit weight. A hot pepper variety with largest fruit weight is an indication of high yielding potential and this character is mainly genetically.

3.2.5. Marketable Green Fruit Yield (tha^{-1})

Marketable fruit yield is the component of total fruit yield and highly affected by unmarketable fruit yield. The marketable green fruit yield results were significantly differed at $p < 0.001$ level of probability (Table 3). This is in agreement with the finding of Melaku *et al*. (2015) [23] who mentioned that there was high significant difference among hot pepper varieties in marketable. Delelegn *et al*. (2014) [10] reported that hot pepper varieties were highly significant different for marketable fruit yield in Jimma and Seka-chekorsa areas. Similarly, Cherne and Zibelo (2019) [6] found that hot pepper varieties evaluated showed significant difference for marketable green fruit yield. Moreover, supporting idea was reported by Gebremeskel *et al*. (2015) [15] who found that significant differences among three varieties evaluated for two years in Raya valley, Northern Ethiopia for marketable fruit yield.

Marketable green fruit yield result (14.79 tha^{-1}, 16.28 tha^{-1}& 18.04 tha^{-1}) were statistically dissimilar due to varietal difference effect and ranged from14.79tha^{-1}- 18.04 tha^{-1}.Marketable green fruit yield of 14.79tha^{-1} tha^{-1}wasresulted from variety Melka shote, 16.28 tha^{-1} from Mareko fanaand18.04 tha^{-1} was from Melka awaze (Table 3). The highest (18.04 tha^{-1}) marketable fruit yield was obtained from variety Melka awaze, an intermediate (16.28 tha^{-1}) was from variety Mareko fan a while the lowest (14.79 tha^{-1}) was caused by variety Melka shote (Table 3).

The difference between the highest and lowest marketable green fruit yield was 3.25 tha^{-1}, however, the difference between highest and an intermediate was 1.76 tha^{-1}.Indicating that variety Melka awaze was superior and produced 17.12% & 9.24% extra marketable green fruit yield over variety Melka shote and Mareko fan respectively. Differences among hot pepper varieties in relation to marketable fruit yield could be due to combined effect of genetic makeup differences and environmental factors. In line with the finding of Tibebu and Bizuayehu (2014) [29] who confirmed that fruit yield influenced by environmental factors like temperature and also yield related traits. Marame *et al* (2008) [8] also reported that the variation in marketable fruit yield of varieties could be due to difference in genetic characteristics and agro ecological adaptability nature. Moreover, a hot pepper variety with the highest marketable fruit yield is implication of best performance and high yielding potential and also these characteristics are mainly genetically.

3.2.6. Unmarketable Green Fruit Yield (tha^{-1})

Unmarketable green fruit yield is the component of total fruit yield. The combined analysis of variance indicated that hot pepper varieties were significantly ($p \leq 0.01$) varied in unmarketable green fruit yield (Table 3). In line with the finding of Melaku *et al*. (2015) [23] who revealed that there was a very high significant difference among the hot pepper varieties in terms unmarketable fruit yield. Unmarketable green fruit yield (tha^{-1}) is obtained by sorting the diseased discolored, shrunken shape and small sized fruits from total fruit yield. Unmarketable green fruit yield also obtained by deducting the marketable fruit yield from the total fruit yield and highly affected by marketable fruit yield. Unmarketable fruit green yield results were arranged in an ascending orders (0.92 tha^{-1}, 1.02 tha^{-1} & 1.08 tha^{-1}) and ranged between 0.92 tha^{-1} -1.08 tha^{-1}.

Difference in unmarketable fruit yield could be due to varietal variability effect. Unmarketable green fruit yield (0.92tha^{-1}) was obtained from variety Mareko fan a 1.02tha^{-1} from variety Melka shote and 1.08tha^{-1} was from variety melka awaze. Hence the highest (1.08tha^{-1}) unmarketable green fruit yield obtained from variety Melka shote followed by variety Melka awaze (1.02tha^{-1}) while the lowest (0.92tha^{-1}) was obtained from variety Mareko fana. Variety Melka shote and Melka awaze shared statistically similar grade in unmarketable green fruit yield. Differences in

unmarketable green fruit yield between varieties Melka shote and Mareko fana was 0.16tha^{-1}. Melka shote caused 14.82% extra unmarketable green fruit yieldas compared to variety Mareko fana.

3.2.7. Total Green Fruit Yield (tha^{-1})

Total green fruit yield is the summation of marketable and unmarketable green fruit yield of hot pepper. Hot pepper varieties were significantly($p<0,001$) differed from one another in total fruit yield (Table 3).Total green fruit yield results(15.87 tha^{-1}, 17.20 tha^{-1}&19.07 tha^{-1}) were ranged from 16.87 tha^{-1}to 19.07 tha^{-1} Due to genotypic variability effect of varieties, total fruit yield values were statistically different. Accordingly, variety Melka shote produced total green fruit yield of 15.87 tha^{-1}, Mareko fana (17.20 tha^{-1}) and Melka awaze (19.07 tha^{-1}). The highest (19.07 tha^{-1}) total fruit yield was recorded from variety Melka awaze, an intermediate (17.20 tha^{-1}) was from variety Mareko fana while the lowest (15.87 tha^{-1}) was obtained from Variety Melka shote. This result is in agreement with the report of Getahun and Habtie (2017) [16] discovered that variety Melka Awaze produced the maximum yields in Woreta, Northwestern Ethiopia. The difference between the highest and the lowest total fruit yield was 3.2 tha^{-1}, but the difference between the highest and an intermediate was 1.87 tha^{-1}. With this, variety Melka awaze was superior and resulted in 15.05% & 7.93% extra total green fruit yield as compared to variety Melka shote and Mareko fan respectively.

Table 3: Combined mean of days to 50% fruiting, number of green fruit per plant, total green fruit weight per plot, single green fruit weight

Hot Pepper Variety Treatments	Days to 50% Fruiting	Number of Green Fruits per Plant	Total Green Fruit Weight per Plot (kg)	Single Green fruit Weight (g fruit^{-1})	Marketable Green Fruit Yield (tha^{-1}	Unmarketable green Fruit yield(tha^{-1})	Total Green Fruit Yield(tha^{-1})
Melka awaze	68b	52.67^{b}	10.68^{a}	5.96^{b}	18.04^{a}	1.02^{a}	19.07^{a}
Melka shote	75.33a	97.67^{a}	8.89^{c}	3.96^{c}	14.79^{c}	1.08^{a}	15.87c
Mareko fana	65.67c	57.00^{b}	9.63^{b}	7.98^{a}	16.28^{b}	0.92^{c}	17.20^{c}
LSD(0.05)	2.07	32.68	0.293	1.55	0.56	0.06	0.51
CV%	8.31	16.86	6.33	11.43	7.52	10.39	5.30
Significant level	***	*	***	**	***	**	***

Marketable green fruit yield, unmarketable green fruit yield and total green fruit yield influenced by hot pepper varieties

Conclusion and Recommendations

Field experiment was conducted from 2018-20 cropping season at hot pepper potential areas of West Hararge highlands aimed at adaptability evaluation of three recently released hot pepper varieties such as Melka awaze, Melka shote and Mareko fan a under supplementary irrigation conditions. West Hararg he highland areas of study site is potential area for hot pepper production. Moreover, at West Hararg he highlands of study area, farmers have been producing hot pepper for consumption and market purposes since right now, however, its productivity and production is low due to lack of improved hot pepper varieties suitable for the study are a and then farmers obliged to use local hot pepper which is low yielder. Thus, productivity and production of hot pepper could be maximized using improved hot pepper variety suitable for the study area. According to the result of this study, variety Melka awaze showed best performance in fruit yield and fruit yield components of hot pepper over the rest varieties evaluated. Therefore, as the variety Melka awaze was superior in these parameters, could maximize productivity and production of hot pepper and recommended for the study site.

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6. References

1 Acquaah G. Horticulture: Principles and Practices. 2nd edition. Prentice Hall of India Private Ltd. New Delhi, India, c2004, p.787
2 Ahmed J, Shivhare US, Raghavan GSV. Rheological characteristics and kinetics of colour degradations of green chilli puree. Journal of Food Engineering. 2000;44:239-244.
3 Assefa G, Girma S, Deresa D. Response of hot pepper (Capsicum annuum L.) as affected by np fertilizer and planting method on yield and yield related traits in West Hararghe zone, Eastern Ethiopia. American Journal of BioScience. 2020;8(4):113-122.
4 Beyene T, David P. Ensuring small scale producers in Ethiopia to achieve sustainable and fair access to pepper market. Uganda Journal of Agriculture. 2007;3(2):113-119.
5 Bosland PW. Chiles: a diverse crop. Hort. Technology. 1992;2:6-10
6 Chernet S, Zibelo H. Evaluation of hot pepper (*Capsicum annuum* L.) varieties for green pod yield and yield components in Western Tigray, Northern Ethiopia. Journal of Plant Breeding and Crop Science. 2019;11(9):260-264.
7 CSA. Agricultural sample survey. 2005/2006 Report on area and production of crops. Statistical bulletin. 2006;1:361. Addis Ababa, Ethiopia
8 CSA (Central Statistical Agency Ethiopia). Report on area and production of major crops. Agricultural sample survey. Addis Ababa Statistical Bulletin. 2018;1(584):14-68.
9 Central Statistical Agency (CSA). Report on area and production of major crops. Agricultural Sample Survey. Addis Ababa; c2017-18.
10 Delelegn S, Belew D, Mohammed A, Getachew Y. Evaluation of elite hot pepper varieties (*Capsicum Sp*.) for growth, dry pod yield and quality under Jimma Condition, South West Ethiopia. International Journal of Agricultural Research. 2014;9(7):364-374.
11 Ethiopian Export Promotion Agency (EEPA). Spice potential and market study product development and Market Research Directorate, Addis Ababa; c2003.
12 FAOSTAT (Food and Agriculture Organization). Food and Agriculture Organization of the United Nations, for a world

without hunger. Rome, Italy; c2017. http://faostat.fao.org /site/567/; c2017.
13 FAOSTAT. Statistical Database of the Food and Agriculture Organization of the United Nations. FAO, Rome, Italy; c2018 August. Available at http://faostat.fao.org.Accessed on.
14 Fekadu M, Dandena G. Review of the status of vegetable crops production and marketing in Ethiopia. Uganda J Agric. Sci. 2006;12(2):26-30.
15 Gebremeskel H, Abebe H, Biratu W, Jelato K. Performance evaluation of hot pepper (*Capsicum annuum* L.) varieties for productivity under irrigation at Raya Valley, Northern, Ethiopia. Basic Research Journal of Agricultural Science and Review. 2015;4(7):211-216.
16 Getahun D, Habtie B. Growth and Yielding Potential of Hot Pepper Varieties under Rain-Fed Production at Woreta, Northwestern Ethiopia. International Journal of Research Studies in Agricultural Sciences (IJRSAS). 2017;3(3):11-18.
17 Mangoel W, Ndam ON, Badi SH, Daar JW, Mamzing D. Evaluation of hot pepper (*Capsicum Spp*) varieties for some growth and yield parameters at Garkawa, Northern Guinea Savanna Zone of Nigeria. In Crop Science Society of Nigeria: Second National Annual Conference Proceedings; c2012. Available at https://africaneditors. *Org/journal/NJCS/abstract D* (Vol. 637016121).
18 Marame F, Desalegne L, Singh H, Fininsa C, Sigvald R. Genetic components and heritability of yield and yield related traits in hot pepper. Res. J Agric. Biol. Sci. 200;84(6):803-809.
19 Kahsay Y. Evaluation of hot pepper varieties (*Capsicum Sp*ecies) for growth, dry pod yield and quality at M/Lehke District, Tigray, Ethiopia. International Journal of Engineering Development and Research. 2017;5(3);15-27.
20 Khan MS, Raj SK. The first report of molecular detection of an Aster yellows phytoplasma (‘Candidatus Phytoplasma asteris’) isolates infecting chilli (*Capsicum annuum*) in India. Plant Pathology. 2006;55:822-822. 10.1111/j.1365-3059.2006.01482.
21 Kinde L, Asfaw Z. Effect of spacing and fertilizer dose on growth and yield of potato (*Solanum tuberosum* L) Gudane variety at West Hararghe, Eastern Ethiopia. International Journal of Horticulture and Ornamental Plants. 2016;2(1): 011-018.
22 MARC (Melkasa Agricultural Research Center). Progress report, Addis Ababa, Ethiopia; c2004.
23 Melaku FT, Alemayehu TG. Lidet BT. Adaptation trail of different improved hot pepper (*Capsicum Species*) varieties under Gedeo Zone, Dilla, Ethiopia. International Journal of Life Sciences. 2015;4(4):216-220.
24 Nigus M, Shimelis H, Mathew I, Abady S. Wheat production in the highlands of Eastern Ethiopia: opportunities, challenges and coping strategies of rust diseases. Acta Agriculturae Scandinavica, Section B—Soil & Plant Science. 2022;72(1):563-575.
25 Purseg love JW, Brown EG, Green CI, Robbins SRI. Spices. LongmanInc. New York. 1981;1(1):365.
26 Rodriguez Yaritza, Depestre Tomas. Gomez Olimpia. The efficiency of selection in pepper lines (*Capsicum annuum*), from four sub-populations, in characters of productive interest. Ciencia e Investigacion Agraria. 2008;35:29-40.
27 Seleshi D, Derebew B, Ali M. Pepper varieties (*Capsicum Sp*p.) for growth, dry pod yield and quality under Jimma condition, South-West Ethiopia. Int. J Agric. Res. 2014:9(7):364-374.
28 Terry Berke, Subodh Joshi. Perspectives of Bell Pepper Breeding, Journal of New Seeds. 2005;6:(2-3):51-74. DOI: 10.1300/J153v06n02_04.
29 Tibebu S, Bizuayehu T. Growth and productivity of hot pepper (*Capsicum annuum* L.) as affected by variety, nitrogen and phosphorous at Jinka, Southern Ethiopia. Res. J. Agric. Environ. Manage. 2014;3(9):427-433.
30 USAID (The United States on America Aid). From Sample Blended Fertilizers to Ample Yields. In: ethioagp.org/from-sample-blended-fertilizers-to-ample-yields; c2013.