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Adaptability and Performance Evaluation of Improved Large Pod Hot Pepper (*Capsicum annum* L.) Varieties in West and Kellem Wollega Zones

Kibiru Kena[1, *], Alemayehu Latera[1], Zewdu Tegenu[2]

[1]Oromia Agricultural Research Institute, Haro Sabu Agricultural Research Center, Haro Sabu, Ethiopia

[2]Oromia Agricultural Research Institute, Fitche Agricultural Research Center, Fitche, Ethiopia

Email address:
kibiruk12@gmail.com (K. Kena), alemayehulatera987@gmail.com (A. Latera), zedtegenu@gmail.com (Z. Tegenu)

[*]Corresponding author

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Abstract: Large pod hot Pepper is solanaceae family widely grown in many parts of Ethiopia. It is grown as an annual crop and produced for its fruits. It is one of the most important vegetable crops for fresh consumption, for processing and as a spice (for making stew). A field experiment was conducted at Haro Sabu Agricultural Research Center on station, Sedi Canqa and Sayo (Meti) sub sites of Kellem Wollega zone, Western Ethiopia, throughout 2019 and 2020 Melka Awaze, Oda Haro and Mareko Fana majorrainy season. Six large pod hot pepper varieties collected from Melkasa and Bako Agricultural Research and one local check variety were used as planting materials. The combined analysis of variance (ANOVA) for total dry pod yield and other agronomic componentsof seven large pod hot pepper varieties grown at three location locations in 2019 and 2020 on days to flowering, days to maturity, plant height, plant canopy length, number of primary branches per plant, number of pod per plants, pod length, total dry pod yield revealed highly significant varietal difference. Likewise there was significant difference of variety on pod weight. The interaction effect of variety, location and year revealed highly significant effect days to maturity and total yield. In the present experiment, Melka Awaze and Oda Haro varieties were found superior in the case marketable yield (dry pod), tolerant to major disease and other important yield related components. ThereforeMelka Awaze and Oda Haro improved varieties are recommended for popularization and demonstration around the studied areasand similar agro-ecologies in the WestWollega and Kellem Wollega zones of hot pepper producing areas under main natural rain fed.

Keywords: Adaptation, Melka Awaze, Mareko Fana, Oda Haro

1. Introduction

Capsicum is a high value crop used as vegetables and spice in Ethiopia. Different pepper types such as bell (sweet) pepper which is non -pungent, chili (mitimita) and hot pepper (berbere) which is pungent are produced in which hot pepper is dominantly produced. The pungency is due to high capsaicin ($C_{18}H_{27}O_3N$) content in the fruit. It is important in local dishes, karia, berbre and processing industries (coloring agent); it is exported in the form of oleoresin (red pigment) and ground powder in different forms [6]. Capsicum is grown in most part of the county. The central (Eastern and Southern Shoa), Western, North Western (Wellega, Gojjam) and the Northern part of the country are the potential capsicum producing areas in the country [6]. Peppers are a warm-season crop and require similar growing conditions as tomato and eggplant. The crop grows at wide range of altitudes with rainfall between 600-1250 mm per annum.

Peppers are widely grown in various parts of Ethiopia and the fruits are consumed as fresh, dried or processed products, as vegetables, as spices or condiments. Today, the crop has not only attained economical, but also traditional importance. It is one component of the daily diet of Ethiopian people.

Peppers are important in the local dishes as 'karia' (green pod), 'berbere' (fine powder from the dry fruits of hot pepper), grinded mature green fruits blended with other spices and 'mitmita', the small very pungent fruits. The powder from dried ripe fruits of hot pepper is used as spice to flavor ‘Wot’, an Ethiopian stew in a daily traditional meal. Mature green pods ('karia') are eaten as salads.

Introduction and selection for best adaptable varieties with high yield and quality as well as resistant to major diseases is therefore a priority and quick approach to contribute towards alleviating major bottlenecks of the existing production system. According to [9], introduction, domestication and commercialization of plants play a major role in improving rural livelihoods through nutritional status, household income, entrepreneurial opportunities and economic empowerment.

The use of unimproved local varieties of low quality and productivity, and soil borne and foliar diseases caused by fungi, bacteria and viruses are among several constraints of the production system for green and dry pod confronted with [2]. Hence, production and productivity of hot pepper is declining and farmers are abandoning pepper production in many places around the study area. This adaptability and performance evaluation of large pod hot pepper varieties was therefore undertaken to identify best varieties for disease resistance /tolerance, high dry pod yield and quality around West Wollega and Kellem Wollega zones of western Oromia.

The diverse climatic soil conditions of Ethiopia allow cultivation of a wide range of fruit and vegetable crops including small pod and large pod hot pepper, which is largely grown in the eastern and central parts of the mid- to low-land areas of the country. However, local production of hot pepper in West and Kelem Wellega zones is not able to meet the domestic demand due to lack of improved variety, diseases and another new technological packages for hot pepper.

Therefore, it is important to evaluate different large pod hot pepper varieties to recommend high fruit yielding and disease tolerant variety/ies for the study area. Thus, the objective of this study was to evaluate the adaptability of large pod hot pepper varieties for high yielding and recommend the best performed variety for production in the studied areas and similar agrological zones.

2. Material and Methods

2.1. Experimental Location and Experimental Material

The experiment was conducted in Haro Sabu Agricultural Research Center of three experimental sites for two consecutive years during 2019 and 2020 main cropping season. Six improved large pod hot pepper varieties collected from Melkassa and Bako Agricultural Research Centers *viz* Melka Zala, Bako Local, Melka Awaze, Melka Shote, Oda Haro and Mareko Fana varieties were evaluated against one local check.

2.2. Experimental Design and Analyses

The experiment was laid out in randomized complete block design (RCBD) with three replications. Each variety was planted in the main field in a gross plot size of 3.5m*3m with recommended spacing of 70cm and 30cm between rows and plants, respectively. The three middle rows were used for data collection leaving the two rows as borders. All agronomic practices (transplanting time, cultivation, weeding and fertilization application) were applied uniformly for all plots according to the recommendation of the crop.

2.3. Data Collection and Data Analyses

Ten plants were randomly sampled from middle three rows. Data on plant height, plant canopy, number of primary branches per plant, number of pods per plant, pod yield per plant (g), average pod weight (g), pod length (cm), pod diameter (cm) were recorded per plant and fruit basis. While measurements such as days to flowering, days to maturity, marketable dry pod yield hectare^{-1} (kilogram) were taken on plot basis.

The collected data were subjected to analysis of variance using GenStat computer software [5] and Least Significant Differences (LSD) was used to compare the varieties using the procedures of Fishers protected at the 5% level of significance.

3. Result and Discussion

3.1. ANOVA

The combined analysis of variance (ANOVA) for phonelogical, growth parameters and yield data of seven large pod hot pepper varieties grown at three locations in 2019 and 2020 revealed significant varietal difference (Tables 5 and 6).

3.2. Days to Flowering and Maturity

From the combined mean of analyses days to 50% flowering and maturity was revealed highly significance on varieties of large pod hot pepper varieties (Table 5). Local variety was the earliest to attain days to flowering and maturity while Malka Zala was the latest (Table 1).

The main differences among varieties on days to flowering and maturity might be genetic factor which either accelerate or lag the life cycle of the crop. This is similar with the work of [7] who reported different flowering and maturity dates for different varieties. However, [12] reported non-significant varietal effect on days flowering and maturity.

3.3. Plant Height

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on plant height and there were a significant effect on year, location, year and their interaction (Table 5). The longest (58.63 cm) and the shortest (46 cm) were recorded from Malka Awaze and Loca check varieties (Table 1). This varietal difference of varieties on plant height might be due to the varietal variability to absorb the nutrients from the soil [13, 3].

Table 1. *Combined mean of yield and yield components of large pod hot pepper varieties.*

Variety	Parameters									
	DF	DM	PH	CL	NPrB	NPPP	PL	PD	PW	TY (Kgha)
Melka Zala	73.33a	153.7a	58.31a	38.67b	2.7a	17.73bc	9.63a	4.66	1.69abc	1228cd
Bako Local	69.22b	153.6a	50.92b	33.56c	2.22b	17.26bc	9.54a	5.94	1.62bcd	1105d
Melka Awaze	66.72bc	139.3d	58.63a	45.8a	2.31b	24.36a	7.77c	4.63	1.52cd	1910a
Melka Shote	66.44cd	141.4d	48.78bc	37.63b	2.28b	20.71ab	8.22c	4	1.38d	1378bc
Oda Haro	64.06de	150.3b	50.63b	39.21b	2.28b	22.87a	8.57bc	4.66	1.64bcd	1573b
Mareko Fana	63.83e	152.8ab	56.07a	40.8b	1.88c	14.46c	8.26c	5.48	1.91a	1445bc
Local Check	57f	144.9c	46c	37.3b	1.64c	14.07c	9.11ab	4.47	1.82ab	1281cd
LSD (0.05)	2.507	2.52	4.07	3.56	0.31	3.92	0.83	NS	0.26	249.85
CV (%)	5.7	2.6	11.6	13.8	21.7	31.5	14.3	42.2	23.5	26.6

Where DF, DM, PH, CL, NPrB, NPPP, PL, PD, PW, TY, LSD (.05) and CV (%) are days to 50% flowering, days to 50% maturity, plant height (cm), canopy length (cm), number primary branches per plant, number of pod per plant, pod length, pod diameter, pod weight, Total yield (Kg/ha), Least significance difference and coefficient of variation respectively.

3.4. Number of Primary Branches Per Plant

Analysis of variance showed that there was a highly significant ($P \leq 0.01$) effect on number of primary branches per plant due to varieties, location, year and interaction of location and year (Table 5). The highest (2.7) and the lowest (1.64) number of primary branches per plant were recorded from Melka Zala and Local Check varieties, respectively (Table 1). This might be due to different plant canopy and growth habit among varieties of the same crop. This result was in line with [11] who reported different branch number per plant of hot pepper varieties.

3.5. Plant Canopy

The analysis of variance showed that there was a highly significant ($p<0.01$) effect on variety, location and interaction of year with location whereas there was a significant ($p<0.05$) effect on the interaction of variety with location (Table 5). The effect of variety revealed highly significance on plant canopy. The widest plant canopy (45.8 cm) and the narrowest (33.56 cm) was recorded from Malka Awaze and Bako Local varieties, respectively (Table 1).

The result indicated that the widest canopy diameters were obtained from variety Melka Awaze (45.8 cm) and the narrowest (33.56 cm) were obtained from Bako Local variety. These variations in canopy diameter between varieties might be due to their inherited traits, the growing environment's soil type, and rainfall and soil pH. This variation on the other hand, may determine the yielding potential of the crop, since, varieties with wider canopy diameter could produce more fruit (pods) than varieties with narrow canopy due to increased number of secondary and tertiary branches which are the locations for fruit bud formation. This is in conformity with the work of [4] who has reported that plants with wider crown produced higher early season yield than those with small crown.

3.6. Number of Pod Per Plant, Pod Length, Pod Diameter and Average Pod Weight

The effect of variety showed highly significant effect on the number of pod per plant and pod length; and significant effect on average pod weight; however effect of variety revealed non-significant effect on pod diameter (Table 6). The highest number of pod per plant (24.36) and the lowest number of pod per plant (14.07) was recorded from Malka Awaze and Local check varieties, respectively. The longest (9.63) and the shortest (8.26) pod length was recorded from Malka Zala and Mareko Fana varieties respectively (Table 1). Similarly highest (1.91) and the lowest (1.38) average pod weight was recorded from Mareko Fana and Malka Shote, respectively (Table 1). The varietal different on pod per plant, pod length and pod weight might be due to individual gene effect of each varieties. The fruit number per plant in this study is in accordance with previous reports by [8] who observed number of pod per plant ranging from 17 to 22 in for large pod hot pepper varieties. It is clear that environmental and genetic factors regulate the number of pod per plant. Similarly [1] found different fruit number per plant due to variety differences.

The significance difference of pod length and average pod weight among varieties may be due to the genetic makeup of the varieties, and or due to the agro-ecological variations in which the varieties were evaluated. Similarly [10] reported varietal differences on pod length and average pod weight of hot pepper varieties.

Table 2. *Major disease reaction of large pod hot pepper varieties.*

Variety	Antracnose	Cercospora leaf spot (frog eye)
MarekoFana	1.33	2b
MelkaShote	1.22	1.89bc
Bako Local	1.11	1.67c
MelkaAwaze	1.11	2.44a
MelkaZala	1.11	2b
OdaHaro	1	1.67c
Local Check	1	1.89bc
LSD (0.05)	NS	0.32
CV (%)	21.9	17.4

3.7. Disease Reaction of Varieties

The major recorded diseases of hot pepper at the studied areas were antracnose and Cercospora leaf spot (frog eye). The main factor of variety not significantly affected by antracnose. However there were a significant effect of variety Cercospora leaf spot (frog eye) disease (Table 2). Generally even though there was a significant almost all varieties are tolerant the major diseases recorded there.

3.8. Total Dry Yield (Kg/ha)

Analysis of variance the main factors variety were highly significant (P<0.01) effect on total yield of large pod hot pepper varieties (Table 6). The highest (1910 Kg/ha) and the lowest (1105 Kg) dry pod yield was recorded from Melka Awaze and Bako Local varieties, respectively (Table 1). The significance difference among varieties on total yield might be due to yield related parameters such as plant canopy length, number of primary branches per plant and number of pods per plant and branch number per plants. This is in line with the findings of [7] who reported the highest dry yield of Malka Awaze variety at Raya valley of Northern Ethiopia. Similarly [2] stated the highest green pod yield of Malka Awaze variety. This is associated with superior vegetative growth including height, plant canopy and tolerance to disease attack. Beside high yielder Malka Awaze and Oda Haro varieties was more stable over year and location than other varieties (Figure 1).

Table 3. *Interaction of variety and year on total yield (Kg/ha) over year.*

Variety	Year	
	2019/20	2020/21
Melka Awaze	2698a	1123f
Oda Haro	2194b	951fg
Mareko Fana	2007bc	883fg
Melka Shote	1959bcd	797fg
Melka Zala	1621de	835fg
Bako Local	1508e	703g
Localcheck	1765cde	796fg
LSD (0.05)	353.33	
CV (%)	26.6	

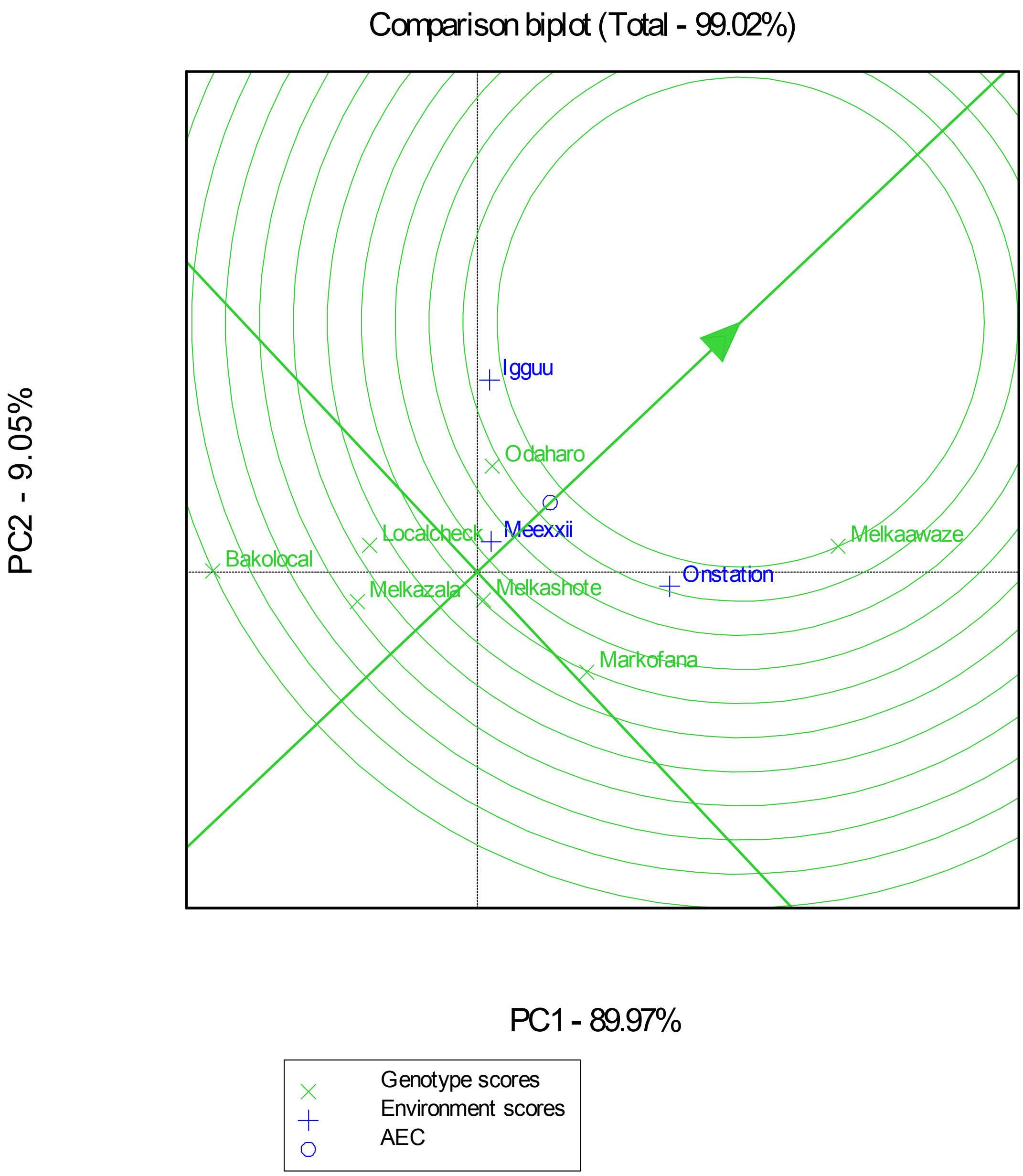

Figure 1. *GGE Biplot stability analysis of large pod hot pepper varieties over location.*

Table 4. Interaction of variety and location on total yield (Kg/ha) over location.

Variety	Location		
	Onstation	SediCanqa (Igu)	Sayoworeda (Mexi)
Melka Awaze	3004a	1402cde	1326def
Mareko Fana	2191b	930f	1214def
Malka Shote	1832bc	1161def	1140ef
Oda Haro	1822bc	1589cd	1306def
Malka Zala	1405cde	1121ef	1159def
Bako Local	907f	1175def	1234def
Local check	1440cde	1327def	1074ef
LSD (0.05)	432.744		
CV (%)	26.6		

3.9. Comparison Plot for Genotypes Based on the Concentric Circle

Figure 1: shows the comparison plot for variety, and an ideal variety is one which is near or at the center of the concentric circle. Hence in this study, the plot reflected that Melka Awaze and Oda Haro are the most ideal varieties as shown by their position. This also reflects that; these varieties have highest dry pod yield and more stable. Good varieties are those which are closer to the ideal varieties. However, Bako local, Melka zala, Local check, Melka shote and Marko fana are the worst varieties as their position in the plot are located far from the concentric circle.

4. Conclusion and Recommendation

The evaluation of large pod hot pepper varieties were carried out to evaluatethe adaptability and performance of improved large pod hot pepper varieties. Significant effect was revealed on a lot of yield related parameters. Melka Awaze, Oda Haro and Mareko Fana within varieties. Malka Awaze variety was the earliest to reach 50% flowering date and physiological maturity date while Malka Zala was the latest. Similarly Malka Zala and Local Check was the longest and shortest varieties respectively. Variety evaluation for adaptation is a quick approach to demonstrate and promote agricultural technology. In the present study, Melka Awaze and Oda Haro varieties were found superior in terms dry pod yield and other yield related traits. These varieties also stable than all other varieties evaluated and toltent to major hot pepper diseases. Therefore Melka Awaze and Oda Haro varieties are recommended for demonstration and wider production in the studied areas and similar agro-ecologies in Western Oromia in general and KellemWollega and West Wollega Zones in particular.

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Appendix

Table 5. Mean squares of ANOVA for days to 50% flowering (DFL), days to 90% physiological maturity (DM), plant height (PH), canopy length (cm), number of primary branches per plant (NPB) of large pod hot pepper varieties.

Source of variation	d.f.	Mean Squares				
		DF	DM	PH	CL	NPrB
Replication	2	27.08	11.01	119.13	88.02	0.80
Variety	6	462.24**	662.23**	437.1**	252.11**	2.06**
Location	2	373.48**	240.1**	276.1*	394.76**	1.85**
Year	1	2605.79**	21790.87**	426.44*	32.31	3.30**
Variety. Location	12	28.85*	41.08*	109.27*	85.41*	0.30
Variety. Year	6	96.88**	315.49**	96.82*	41.13	0.26
Location. Year	2	19.45	4386.44**	274.37*	492.99**	8.38**
Variety. Location. Year	12	90.96**	42.21*	62.9	29.03	0.29
Residual	82	14.29	14.46	37.71	28.8	0.22
CV (%)		5.7	2.6	11.6	13.8	21.7

df= degree of freedom; * and **significant at 5% and 1% level of significance, respectively.

Table 6. Mean squares of ANOVA for number of pods per plant (NPPP), Pod length (PL), Pod diameter (PD), Pod weight (PW) and total yield (TY) of large pod hot pepper varieties.

Source of variation	d.f.	Mean Squares				
		NPPP	PL	PD	PW	TY ($Kgha^{-1}$)
Replication	2	116.76	0.358	3.882	0.3027	366382
Variety	6	287.56**	9.179**	7.694	0.563*	1264066**
Location	2	11.42	8.149*	25.656*	0.2625	4633625**
Year	1	45.84	1.522	0.647	0.1283	37743948**
Variety. Location	12	91.51*	2.261	4.451	0.2636	873829**
Variety. Year	6	62.82	1.621	5.431	0.2113	340525*
Location. Year	2	1518.08*	53.706**	2.268	2.1546**	11168473**
Variety. Location. Year	12	77.04*	0.564	3.389	0.1185	453463**

Source of variation	d.f.	Mean Squares				
		NPPP	PL	PD	PW	TY ($Kgha^{-1}$)
Residual	82	34.88	1.556	4.157	0.1512	141963
CV (%)		31.5	14.3	42.2	23.5	26.6

df= degree of freedom; * and **significant at 5% and 1% level of significance, respectively.

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