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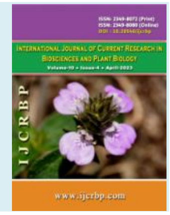

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Evaluation of small pod pepper varieties (*Capsicum frutescens* L.) at Kellem Wellega and West Wellega zones

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Abstract

Small pod hot pepper (chili pepper) is a seasonal plant of the family Solanaceae. It is grown as an annual crop and produced for its fruits (pods). It is one of the most important vegetable crops for fresh consumption (as chilies), for processing and as a spice (for making stew)and it the main source of income. A field experiment was conducted at Haro Sabu on station and Meti (Sayo Woreda) sub sites of Kellem Wollega zone, Western Ethiopia, during the 2018/2019 and 2019/2020 main cropping season. A total of five small pod hot pepper varieties collected from Melkasa and Bako Agricultural Research centers and one local check variety were used as testing materials. The combined analysis of variance (ANOVA) for total yield and other agronomic traits of six small pod hot pepper varieties grown at two locations revealed significant difference on days to flowering, days to maturity, number of primary branches per plant, number of fruit (pods) per plant, fruit diameter, fruit length and fruit weight total pod dry weight. Likewise there was highly significant difference of variety on pod anthracnose and cercospora leaf spot (frog eye). In this experimentation, Melka Oli and Melka Dera Dinsire varieties were found superior in terms of total dry pod yield and other important yield related parameters. Melka Oli and Melka Dera varieties are also tolerant to major hot pepper diseases. Thus these varieties were recommended for demonstration and wider production in the studied areas and similar agro-ecologies in the Western Oromia in particular and hot pepper producing regions of Ethiopia in general under main natural rain fed condition.

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Introduction

Background and justification

Hot pepper is a seasonal plant of the family *Solanaceae*. It is grown as an annual crop and produced for its fruits. It is one of the most important vegetable crops for fresh consumption (as chilies), for processing and as a spice (for making stew). It is also a very important crop for spice extraction since it has a lot of Oleoresin for dying of food items. Dried peppers may be reconstituted whole, or processed into flakes or powders. Chili or *C. frutescens* (known as barbaré) is important to the national cuisine of Ethiopia, at least as early as the 19th century, "that it was cultivated extensively in the warmer areas wherever the soil was suitable." In Ethiopia, pepper grows under warm and humid weather conditions and the best fruit is obtained in a temperature

21-27^{o}C during the daytime and 15-20^{o}C at night IAR, (1996). It is extensively grown in most parts of the country, with the major production areas concentrated at altitude of 1100 to 1800 m.a.s.l. MoARD, (2009). It is one of the major vegetable crops produced in Ethiopia and the country is one of a few developing countries that have been producing paprika and *capsicum* oleoresins for export market. Because of its wide use in Ethiopian diet, the hot pepper is an important traditional crop mainly valued for its pungency and color. The crop is also one of the important spices that serve as the source of income particularly for smallholder producers in many parts of rural.

The present situation indicates that in study area there are no improved small pod hot pepper varieties; however hot pepper producer used local cultivar with production per unit areas compared to national average yield. As a result, varietal information for the improvement of the crop for high fruit yield and quality in the existing agro ecology is insufficient. There has also been no research on evaluation of hot pepper which enables the growers to select the best performing varieties in the study area.

Evaluation of selected varieties are therefore one of the considerations to ease the existing problems of obtaining the desired varieties for which the output of this study was likely to assist and sensitize hot pepper growers and processors, furthermore the increasing demand for hot pepper to feed the growing human population and supply the ever-expanding pepper industries at national and international level has created a need for the expansion of pepper cultivation in to areas where it has not ever been extensively grown Beyene and David, (2007).

Better adaptable and well performing variety (varieties) with improved cultural practices could be a possibility to boost quality and marketable production of the crop, so that the farmers benefited by cultivating those adaptable improved verities in the study area. Therefore, present study was initiated with the objective of investigating the performance and adaptation of different varieties of hot pepper for growth and yield of small pod hot pepper varieties for the study area.

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 small 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 performance of small pod hot pepper varieties and recommend the best performed variety for production in the studied areas and similar agrological zones.

Materials and methods

Experimental sites, designs and materials

A field experiment was conducted at Haro Sabu Agricultural Research center on main station and Meti (Sayo Woreda) sub sites of Kellem Wollega zone in Western Ethiopia, during the 2018/2019 and 2019/2020 main cropping season. A total of five small pod hot pepper varieties *viz*., Kume, Dinsire, Dame, Melka Dera and Melka Oli were collected from Bako and Melkasa Agricultural research centers and evaluated with one local cultivar. The experiment was laid out in a randomized complete block design with three replications and with plot size of 3.5m length and 3m width. All other agronomic management practices were used uniformly to all varieties as recommended for the crop. Inter and intra row spacing of 70cm and 30cm were used respectively. 200kg/ha DAP and 100kg/ha urea fertilizers were used for all treatments uniformly.

Data collection and statistical analysis

Data were collected in plot, plant and pod basis. Days to 50% flowering, days to 90% maturity and total dry pod yield were plot based data; whereas plant height, number of primary branches per plant, number of fruits(pods) per plant were plant based data and; pod diameter, pod length and pod weight were pod based data. Besides these parameters major hot pepper disease such as pod anthracnose and cercospora leaf spot blight were recorded. All the collected data were subjected to analysis of variance using GenStat computer software (Gen Stat, 2016) and Least Significant Differences (LSD) was used to compare the varieties using the procedures of Fishers protected at the 5% level of significance.

Results and discussion

The combined analysis of variance (ANOVA) for dry pod yield and other yield related parameters of six small pod varieties grown at two locations in 2018/2019 and 2020 revealed significant varietal difference for all considered traits on varieties and their interaction with location. The main effect of variety revealed a significant effect on fruit diameter, fruit length, and number of primary branches per plant, number of pod per plant, pod anthracnose and cercospora leaf spot blight..

Days to flowering

The analysis of variance showed that there was a highly significant effect($p<0.01$) on days to flowering due to main factors of variety, location and year; and the interaction effect of location and year (Table 1). The highest (86.08) and the lowest (73.92) (Table 3) days to flowering was record from in Melka Dera and Melka Oli varieties respectively.

Earliness or lateness in the days to 50% flowering might be to the inherited characters, early acclimatization of different cultivars to the growing area and environmental conditions such as temperature, moisture and soil fertility which enhance growth and developments plants.

This result was in agreement with the finding of Berhane et al. (2016) who reported that significant effect of varieties on large pod hot pepper varieties at northern Ethiopia. Earliness to flowering may be due to inherent characters, different response of varieties to growing environments (e.g. temperature, rainfall, altitude, pests and diseases, etc.), and acclimatization to the growing area and/or due to transplanting disturbance (Sam-Aggrey and Bereke-Tsehai, 2005).

Days to maturity

Analysis of variance showed all the main effects and interaction effects were highly significant ($p<0.01$ on days to maturity (Table 1). The highest (175.7)days to maturity were recorded from Melka Oli variety and lowest (157.0) days to maturity was recorded Dinsire variety (Table 3) This variation ascribed to the differences in the growing environment climatic conditions and genetic make-up of the varieties. This agrees with the report of Seleshi et al., (2014). Moreover, this finding was in agreement with Haileslassie et al., (2015) who reported that days to maturity were significantly affected by pepper varieties.

Plant height (cm)

Plant height significantly ($P<0.05$) influence due to varieties, location and interaction effect of location and year (Table 1). The longest (63.19cm) and the shortest (38.62) plant height was recorded from Melka Oli and Dame varieties, respectively (Table 3).The significant different of varieties on plant height might be due genetic makeup. This result was in agreement with the finding of MARC (2005), which reported different plant height for different varieties. Similarly the current result is similar with the findings of Berhane et al., (2016) who reported the longest (50.33cm) and the shortest (37.33) plant height were recorded for Weldele and Melka Zala varieties, respectively.

Number of primary branches per plant

Analysis of variance showed that there was a significant ($P \leq 0.05$) effect on number of primary branches per plant due to varieties and year. Location and all interactions was no significant (Table 1). The highest (4.46) and the lowest (2.60) number of branches per plant were recorded from Melka Dera and Dame varieties, respectively (Table 3). This might be due to different plant canopy among varieties of the same crop. This result was in line with Seleshi et al. (2014) who reported different branch number per plant of hot pepper varieties. Generally, the differences observed in branching of pepper plants might have been due to genetic variations existed between varieties and or due to favorable influence of organic and inorganic nutrients present in the soils or the growing environment which goes in line with the findings of (El-Tohamy et al., 2006), that stated the presence of adequate amount of organic nutrients in the soil improves growth of pepper plants.

Number of pod (fruit) per plant

Analysis of variance revealed that there was a significant ($P \leq 0.05$) difference on pod number per plant of on the main effect of varieties. The main effects location and year, and all the interactions were non-significant (Table 2). The highest (85.77) and the lowest (29.69) number of pod (fruit) per plant were recorded from Melka Oli and Dame varieties, respectively (Table

4). This might be due to the highest number of primary branches of Melka Oli variety and genetic character which influence number of pod per plant. The highest pod number in Melka Oli variety was most likely due to the pod bearing capacity of the variety and more branch formation nature which leads to hold high number of pod per plant. In line with this result, Amare et al., (2013) found different pod number per plant due to varietal differences. Furthermore, Seleshi et al. (2014) reported that number of pod per plant was highly affected by the interaction of variety by location and they stated that differences among pod number might be due to the associated traits like canopy diameter that could limit the number of branches, the temperature stress of the growing environment and the capability of each varieties to with stand the stress especially on the reproductive development, which is more sensitive to high temperature stress (day and night temperature) than vegetative development.

Pod diameter

The main effect of variety, location and year as well as the interaction effect of location and year showed significant ($P \leq 0.05$) effect on pod diameter (Table 2). The highest (3.90cm) and the lowest (3.23cm) pod diameter were recorded from Dame and Melka Oli varieties, respectively (Table 4). The difference in pod diameter among the varieties might be due to the dissimilarity of each variety to absorbed ample solar radiation which resulted in more accumulation of photosynthetic assimilates. This in turn had an impact in partitioning of dry matter to wider pod diameter formation. This result was related with work of Haileslassie et al., (2015) who found that pod diameter was significantly affected due to hot pepper varieties. Similarly, the recurrent study was related with the findings of Shushay and Haile (2019) who reported that the highest (15.6mm) and the lowest (8.3mm) pod diameter for Marekofana and Melka Shote hot pepper varieties, respectively.

Pod length

The analyzed result revealed that there was highly significant ($P \leq 0.01$) effect of varieties on pod length whereas other main effects and all the interactions were non-significant (Table 2). The longest (6.4cm) and shortest (3.46cm) pod length of small pod pepper varieties were observed from Melka Dera and Kume varieties, respectively (Table 4). The significant difference in pod length among hot pepper varieties might be attributed to the inherited traits and adaptability to the environmental condition of the study area. This current result was supported by the findings of Haileslassie et al. (2015) and Seleshi et al. (2014) who reported significant pod length for different hot pepper varieties. Further, Setiamihardja and Knavel (1982) indicated that pod length and pod diameter were quantitatively inherited and governed by additive gene action in crosses of *Capsicum annuum*. Similarly, Shushay and Haile (2019) reported significant effect of hot pepper varieties on pod length in which the longest (78.8mm) and the shortest (66.3mm) pod length was recorded from Melka Shote and Oda Haro varieties, respectively.

Dry pod weight

The main effect of variety, location and year as well as the interaction effect of variety and year, location and year revealed significant ($P \leq 0.05$) effect on the average dry pod weight of hot pepper (Table 2). Accordingly, the highest (0.68 gram) and the lowest (0.45 gram) pod weight were obtained from Local check and Kume varieties, respectively (Table 4). The significant difference of variety on pod weight might be due to genetic, makeup of the variety since characteristics, such pod length, pod diameter and pod weight are mostly influenced by genetic factors and environmental factors such as sunlight and moisture.

This result is similar with the finding of Berhane et al., (2016) who reported significant effect of hot pepper varieties on dry pod weight in which the highest (12 gram) and the lowest (5 gram) dry pod weight were recorded from Melka Shote and Melka Zala varieties, respectively. Similarly the current result was in line with the work of Kibiru et al. (2021) who reported significant effect of varieties on dry pod weight in which the highest (1.91gram) and the lowest (1.38 gram) dry pod weight were recorded from Marekofana and Melka Shote hot pepper varieties, respectively.

Disease reaction

Analysis of variance showed there was a significant ((P $\leq$ 0.05) difference on the major diseases among small pod hot pepper varieties and there was no significant effect due to location, year and their interaction (Table 2). This might be due to genetic characters which makes individual varieties tolerant to major diseases.

Table 1. Mean squares of ANOVA for days to 50% flowering (DFL), days to 90% physiological maturity(DM),number of primary branches per plant(NPB), plant height(PH) and number of pods per plant (NPPP) of small pod hot pepper varieties.

Source of variation		Mean squares				
	DF	DFL	DM	NPB	PH	NPPP
Replication	2	223.347	13.722	3.8306	691.84	5453
Variety	5	220.647**	678.581**	4.8307**	1164.99**	4669**
Location	1	2951.681**	561.125**	0.7476	1828.73**	80.8
Year	1	7060.681**	3828.125**	7.668*	295.5	533.9
Variety.Location	5	16.714	50.692**	0.5776	51.95	468.2
Variety.Year	5	16.714	50.692**	0.3458	198.57	1048.8
Location.Year	1	2951.681**	561.125**	0.7476	1828.73**	80.8
Variety.Location.Year	5	16.714	50.692**	0.5776	51.95	468.2
Error	46	9.898	8.519**	0.6764	83.74	557.9
CV (%)		4	1.8	22.1	17	27.4

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

Table 1. Mean squares of ANOVA for pod diameter (PD), pod length (PL), pod weight (PW) total dry pod yield(TY), frog eye (FE) and pod anthracnose(PA) of small pod hot pepper varieties.

Source of variation		Mean squares					
	DF	FD	FL	FW	TY	FE	PA
Replication	2	0.701	1.2879	0.10907	1212169	0.6667	0.1285
Variety	5	0.6387*	12.4682**	0.07148*	3129467**	1.6000	1.7806**
Location	1	2.4679*	0.1587	0.4462**	14884840**	0.0000	0.2222
Year	1	2.6412*	0.1991	0.26742*	8231826**	0.0000	0.2222
Variety.Location	5	0.0673	0.1734	0.02005	1915272**	0.0000	0.0806
Variety.Year	5	0.3707	2.0606	0.08814*	248091	0.0000	0.0806
Location.Year	1	2.4679*	0.1587	0.4462**	2909163**	0.0000	0.2222
Variety.Location.Year	5	0.0673	0.1734	0.02005	435183*	0.0000	0.0806
Error	46	0.233	0.9814	0.02494	139996	0.0580	0.1756
CV (%)		13.5	19.9	27.4	19.3	18.1	30.8

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

Table 3. Combined mean of growth parameters for small pod hot pepper varieties.

Variety	DF	DM	PH	NPB
Malka Dara	86.08a	175.7a	62.48a	4.46a
Melka Oli	82.17b	165.6b	63.19a	3.92ab
Kume	78.58c	162.4c	46.09cd	3.45b
Local Check	78.17c	174.3a	59.4ab	4.03ab
Dinsire	76.67c	157d	52.88bc	3.84ab
Dame	73.92d	160.9c	38.62d	2.60c
LSD	2.6	2.4	7.52	0.68
CV	4	1.8	17	22.1

Where DF, DM, PH and NPrB are days to 50% flowering, days to 50% maturity, plant height(cm) and number primary branches per plant, respectively. Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significant; LSD (0.05) = Least Significant Difference at 5% level; CV= Coefficient of variation.

Table 4. Combined mean of Yield and yield components parameters for small pod hot pepper varieties.

Variety	NPPP	PL	PD	PWt	TY(Kg/ha)
Malka Dara	67.6ab	6.40a	3.64ab	0.61a	1246b
Malka Oli	85.77a	5.68ab	3.23c	0.55ab	2013a
Kume	44.58cd	3.46d	3.58abc	0.45b	470d
Local Check	56.3bc	4.49c	3.65ab	0.68a	1189b
Dinsire	45.56cd	5.23bc	3.40bc	0.58a	1208b
Dame	29.69d	4.68c	3.90a	0.59a	859c
LSD	19.41	0.81	0.40	0.13	307.47
CV	43	19.9	13.5	27.4	32.1

Where NPPP, PL, PD,PW and TY number of pod per plant, pod length, pod diameter, pod weight and total dry pod yield(Kg/ha), respectively. Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significant; LSD (0.05) = Least Significant Difference at 5% level; CV= Coefficient of variation.

Table 2. Disease reaction of small pod hot pepper varieties.

Variety	Frog eye	Pod antracnose
Dinsire	2a	1.708ab
Dame	1.333b	1.875a
Local Check	1.333b	1c
Melka Oli	1.333b	1.5b
Kume	1c	1c
MelkaDera	1c	1.083c
LSD	0.198	0.344
CV	18.1	30.8

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significant; LSD (0.05) = Least Significant Difference at 5% level; CV= Coefficient of variation.

Among the major diseases; pod anthracnose and cercospora leaf spot blight were recorded at 1-5 disease scoring scale. From the result (Table 5) Melka Dera, Melka Oli, Kume and Local Check varieties had lower disease reaction to major hot pepper diseases recorded (pod anthracnose and cercospora leaf spot blight) and they are tolerant to these diseases whereas Dame and Dinsire varieties had a higher disease reaction which showed they are the most sensitive to the major hot pepper diseases.

Total Dry Pod Yield (Kg/ha)

Analysis of variance revealed that all the main factors and interactions were highly significant (P<0.01) effect on total dry pod yield of small pod hot pepper varieties (Table 2). The highest (2013Kg/ha) and the lowest (859Kg/ha) dry pod yield was recorded from Melka Oli and Dame varieties, respectively (Table 4). The significance difference among varieties on total dry pod yield might be due to yield related parameters such as number of pods per plant and branch number per plants. Also the variation of dry pod yield of these varieties could be due to difference in genetic characteristics and agro ecological adaptability nature which is in line with the findings of Fekadu et al., (2008) and heritability is necessary in systematic improvement of hot pepper for pod yield and other related traits. Similarly Shushay and Haile (2019) reported significant effect of varieties on green pod in which the highest (19.47tha^{-1}) and the lowest (13.36t/ha^{-1}) green pod was recorded from Jeju and Oda Haro varieties, respectively.

Comparison plot for genotypes based on the concentric circle

Fig. 1 shows the comparison plot for variety, and an ideal variety is one which is nearest to the center of the concentric circle. Hence in this study, the plot reflected that Melka Oli and Melka Dera 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, Kume, Dame and Local check, varieties are the worst varieties as their position in the plot are located far from the concentric circle.

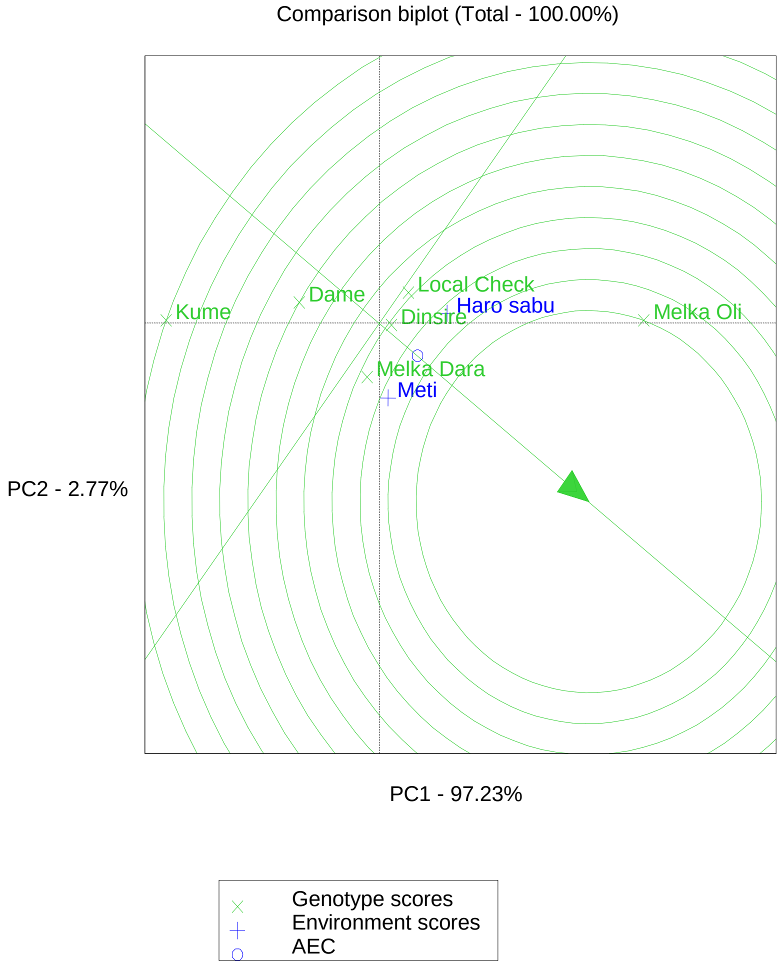

Fig. 1: GGE Biplot stability analysis of small pod hot pepper varieties over location.

Conclusion and Recommendation

The evaluation of small pod hot pepper varieties were done to evaluate the adaptability and performance of recently resealed small pod hot pepper varieties from different research centers. Significant difference was shown different yield related traits among varieties. Dinsire and Dame were the earliest varieties to reach 50% days to flowering and days to physiological maturity whereas Melka Oli and Melka Dera varieties were the latest. The highest number of pod per plant was recorded from Melka Dera and Melka Oli which leads to the highest dry pod per hectare. Generally in the current study, Melka Oli and Melka Dera varieties were found superior in terms dry pod yield and other yield related traits. These varieties also stable than all other varieties evaluated and tolerant to major hot pepper diseases (pod anthracnose and cercospora leaf spot blight). Therefore Melka Oli and Melka Dera varieties are recommended for demonstration and wider production in the studied areas and similar agro-ecologies in Western Oromia in general and particularly in KellemWollega and West Wollega Zones.

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