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Evaluation of hot pepper (*Capsicum annuum* L.) varieties for green pod yield and yield components in Western Tigray, Northern Ethiopia

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A field experiment was conducted at Humera Agricultural Research Center experimental site for two consecutive years (2011/2012 and 2012/2013 cropping season) under irrigation condition to evaluate performance of hot pepper varieties for green pod yield and yield components in western Tigray, Northern Ethiopia. A total of six hot pepper varieties were used as test genotypes. Least Significant Difference (LSD) and Pearson correlation were used to compare treatment means and association of characters. Combined analysis of variance explained that all the traits except days to 50% flowering and days to 50% fruiting showed highly significant difference ($p<0.01$) among the varieties. Among the six varieties the highest marketable green pod yield was found from Jeju (19.47 t ha $^{-1}$) which is statistically at par with marecofana (19.35 t ha $^{-1}$). Marecofana scored the largest green pod weight (7.3 gram) followed by Jeju (6.2 g). Correlation analysis showed that marketable green pod yield per hectare had highly significant positive association with fruit yield per plant (r=0.705), single fruit weight (r=0.668) and fruit diameter (r=0.675) indicating that selection based on these trait improves marketable green pod yield of hot pepper in the specific agroecology.

Key words: Humera, Jeju Marecofana, Pearson correlation.

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 (Girma et al., 2001). 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 (Girma et al., 2001). 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.

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Seeds germinate best at 25-30°C. Optimal temperatures for productivity range between 18-30°C. Peppers are tolerant to a wide range of soil conditions. However, fertile medium loams and well-drained soils with a pH of 5.5-6.8 are generally considered most suitable (Brandenberger et al., 2012).

Pepper is one of the most important vegetable crops in the world. In 2018 the total cultivated area under pepper in Ethiopia was 8001 hectare with a production quantity of 4889 tons (FAOSTAT, 2018). Tigray region is one of the potential areas for cultivation of the crop. In 2017/2018 the total area covered by green pepper was 689.28 hectare with a production quantity of 40,571.18 quintal (CSA, 2018)

The productivity of the crop in Ethiopia is 6.11 t ha^{-1} (FAOSTAT, 2018) and in Tigray 4.06 ton ha^{-1}(CSA, 2018) which is very low as compared to the national average. The major reasons associated with yield reduction are shortage of improved varieties, infestation of disease and pests, poor agronomic practices, poor post-harvest handling. To reduce the production challenges of hot pepper the Ethiopian Agricultural Research Institute has so far released a number of varieties that include 3 for fresh and dry market and 2 for fresh market (green fruit) and 2 for processing. Moreover, many authors viz; Tegene, 2009; Melakui et al. (2015), Tibebu and Bizuayehu (2014); Gebremeskel et al. (2015); Kirk and Gu (2011); Keneth (2017); Sameer et al. (2017) and Sibhatu et al. (2016) have studied evaluation trial of hot pepper varieties for specific agro ecology However, in the study areas farmers used to grow unknown sources of seed. This revealed no effort was made to recommend agro ecologically adaptable, better quality and high yielding pepper variety for the specific area. Thus, the objective of this study is to evaluate performance of nationally released hot pepper varieties and recommend adaptable and high yielding variety/ies for Western Tigray.

MATERIALS AND METHODS

Experimental location

The experiment was conducted in Humera Agricultural Research Center experimental site, Northern Ethioipia for two years 2011/2012 and 2012/2013 cropping calendar under irrigation. The experimental site is located at 14° 06' N latitudes and 38° 31' E longitudes with an altitude of 604 meter above sea level. It has chromic vertisol black color. Agro-ecologically it is described as hot to warm semiarid plain sub agro-ecology (SA1-1). The mean maximum temperature varies from 42°C in April to 33°C in August, while the mean minimum temperature is from 22.2°C in May to17.5°C in July (EARO, 2002).

Experimental material

The experimental materials comprise five hot pepper varieties obtained from Melkassa Agricultural Research Center (Marecofana, Melkaawaze, Bakolocal and Odaharo) and one cultivar widely used by farmers (Jeju).

Experimental design and management

The trial 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 14 m^2 (5 rows * 4 m row length* 0.7 m spacing between rows). Spacing between row and plants was maintained at 70*30 cm, respectively. The middle three rows were used for data collection leaving the two rows as borders. All agronomic practices (irrigation, cultivation, weeding and fertilization) were applied uniformly for all plots according to the recommendation of the crop.

Data collection

Ten plants were randomly sampled from middle three rows. Data on number of green pods per plant, pod yield per plant (g), single green pod weight (g), pod length (mm), pod width (mm) were recorded per plant and fruit basis. While measurements such as days to flowering, days to maturity, marketable green pod yield $hectare^{-1}$ (tons) were taken on plot basis.

Data analysis

Statistical analysis was done using statistical analysis software (SAS version 9.2) package (SAS Institute, 2008) and treatment means were compared using least significant difference (LSD) at 5% probability level. Pearson correlation was used to measure association of characters among themselves and green pod yield per hectare. Correlation analysis was done using Proc Corr procedures of SAS.

RESULTS AND DISCUSSION

Two years combined analysis of variance on evaluation of hot pepper varieties demonstrated that there were significant differences ($p<0.01$) among the varieties for number of fruits per plant, green pod yield per plant, pod weight, pod length, pod diameter and marketable green pod yield. While days to 50% flowering and 50% fruiting showed nonsignificant differences among the varieties (Table 1). This might be because divergent genotypes are included in the evaluation trial. In line with this, Delelegn et al. (2014) reported highly significant different for days to 50% flowering, days to first harvest, number of fruits per plant, fruit length, fruit width and marketable yield for 9 varieties evaluated in Jimma and Seka chekorsa areas of Ethiopia. Similarly, Mangoel et al. (2012) found significant difference among seven varieties for days to first flowering, number of fruits per plant and fresh fruit yield per hectare. Moreover, Gebremeskel et al. (2015) found significant differences among three varieties evaluated for two years in Raya valley, Northern Ethiopia for plant height, fruit diameter, fruit length and marketable fruit yield. The combined mean value of the six varieties evaluated in western lowland of Tigray showed a wide range of variation for most of the traits.

Table 1. Combined mean square results of pod yield and yield components of hot pepper varieties obtained from ANOVA.

Source of variation	Df	Mean square							
		Days to 50% flowering	Days to 50% fruiting	No. of green pods per plant	Green pod yield per plant (g)	Single green pod weight (g)	Pod length (mm)	Pod diameter (cm)	Marketable green pod yield (t ha^{-1})
Block	2	0.151	92.13	103.2	10865	0.2677	171.91	4.133	8.962
Varieties	4	8.670ns	70.99ns	1033.2**	62344**	5.9601**	114.58*	41.113**	46.171**
Year	1	383.83**	15.28ns	87.7ns	1249920**	3.0959**	867.70**	75.632**	52.396**
Variety*year	4	28.314	99.13*	385.5*	109752**	2.6327**	14.81ns	4.855ns	4.286ns
Residual	18	4.724	33.55	106.7	72679	0.344	36.57	2.539	2.439
Total	29								

Df= degree of freedom, **=highly significant at (p< 0.01), *= significant at (p< 0.05) and ns=non-significant at (p< 0.05) probability level respectively, cm= centimeter, mm= millimeter, g= gram.

This might be the difference of the genotypes in expressing their genetic potential to the specific agro ecology.

Combined mean response showed that Odaharo was the earliest (67days) in days to 50% fruit setting and jeju was the late one (76 days). The highest number of green pods per plant (143) was scored from bako local, but statistically at par with Jeju (134) and Marecofana (135) varieties; while Melka awaze scored the least (109) number of green pods per plant. The highest green pod yield per plant was obtained from Marecofana (608.7 g), which is statistically not significant with jeju (576.5 g) and the least yield was observed from Odaharo (357.3 gram). In addition, Marecofana had the largest fruit size (7.3 g) while Melkashote had the least pod weight (4.5 g). The finding is in agreement with the result of Awole et al. (2011) who reported wide range of pod size difference (6.6-17.0 gram) for five hot pepper varieties evaluated in Diredawa, Ethiopia.

The highest marketable green pod yield was recorded from Jeju (19.47 t ha $^{-1}$) which is statistically at par with Marecofana (19.35 t ha $^{-1}$) whereas, the least yield was obtained from Odaharo (13.36 t ha $^{-1}$) (Table 2). Similar result was also reported by Delelegn et al. (2014) who found a wide range of variation on marketable fruit yield (5.11 -19.00 qt ha^{-1}) for nine varieties of hot pepper varieties. Tesfaw et al. (2013) also obtained significant fresh fruit yield difference (6.42 and 10.92 t ha^{-1} for Melkazala and Marecofana varieties) of hot pepper varieties evaluated in Bure, Northwestern Ethiopia. Moreover, Awole et al. (2011) found a wide range of mean marketable yield variation (6.6-20.0 t ha^{-1}) for five hot pepper varieties.

Pearson correlation (r) of marketable green pod yield with other traits revealed that marketable yield (t ha $^{-1}$) had a very highly significant positive correlation with fruit yield per plant (r=0.705), fruit diameter (r=0.675) and single fruit weight (r=0.668). On the contrary, it had highly significant negative correlation with days to 50 % flowering (r=-0.485) (Table 3). This indicated that fruit yield per plant, fruit diameter and single fruit weight the most important yield component traits in the specific agroecology showed that any improvement in these traits increases marketable green pod yield per hectare. This is in agreement with the finding of Yadeta et al. (2011) who report a highly significant positive association of fruit yield ha^{-1} with fruit weight, fruit diameter and fruit length. Similarly, Zhani et al. (2015) obtained a highly significant positive interrelation of single fruit weight with fruit diameter. Association among other characters indicated that days to 50% flowering had highly significant negative correlation with fruit length (r=-0.573), fruit diameter (r=-0.527) and fruit yield per plant (r=-0.716). While single green pod weight had highly significant positive interrelation with fruit diameter (r=0.784) and fruit yield per plant (r=0.576) (Table 3).

Conclusion

Of the six hot pepper varieties evaluated in Humera Jeju scored highest marketable green pod yield (19.47 t ha^{-1}), which was statistically at par with yield of Marecofana (19.35 t ha^{-1}). Traits

Table 2. Combined mean response of hot pepper varieties for growth, marketable green pod yield and green pod characteristics.

Variety	Days to 50% flowering	days to 50% fruiting	No. of green pods per plant	Pod yield per plant (g)	Single pod weight (g)	Pod length (mm)	Pod diameter (mm)	Marketable green pod yield (t ha^{-1})
Jeju	40	76^{a}	133.6^{a}	576.5^{a}	6.2^{b}	74.6^{a}	13.5^{b}	19.47^{a}
Markofana	40	75^{a}	135.4^{a}	608.7^{a}	7.3^{a}	75.4^{a}	15.6^{a}	19.35^{a}
melka awaze	42	75^{a}	109.2^{b}	504.4^{b}	6.1^{b}	77.5^{a}	11.8^{b}	14.66^{b}
Melkashote	42	75^{a}	118.1^{b}	384.6^{cd}	4.5^{d}	78.8^{a}	8.3^{c}	14.44^{b}
Bako local	42	72^{ab}	142.9^{a}	443.5^{bc}	5.0^{cd}	74.4^{a}	9.9^{c}	13.97^{b}
Oda haro	43	67^{b}	116.9^{b}	357.3^{d}	5.5^{bc}	66.3^{b}	12.7^{b}	13.36^{b}
SEM(+)	0.9	2.4	4.2	23.46	0.24	2.47	0.65	0.638
CV (%)	5.2	7.9	8.2	12	10.2	8.1	13.3	9.8
Level of sig.	ns	*	**	**	**	*	*	**

SEM= standard error of the mean, CV= coefficient of variation ns= non-significant, *=significant, **=highly significant, g=gram, mm= millimeter, t ha^{-1}= ton per hectare. Means in the same columns connected by the same letter are not significantly different at p≤0.05.

Table 3. Pearson correlation (r) of marketable green pod yield and yield components of hot pepper varieties evaluated in Humera.

	DFl	DFr	NGPP	SPW	FL	FD	FYPP	YLD
DFl		0.001	-0.064	-0.302	-0.573**	-0.527**	-0.716**	-0.485**
DFr			0.198	-0.221	0.057	-0.217	-0.038	-0.006
NGPP				0.089	-0.058	0.012	0.109	0.311
SPW					0.21	0.784**	0.576**	0.668**
FL						0.231	0.572**	0.399*
FD							0.664**	0.675**
PYPP								0.705**
YLD								

DFl= days to 50% flowering, DFr= days to 50% fruit setting, NPPP= number of green pods per plant, SPW= single green pod weight, FL= fruit length, FD= fruit diameter, PYPP= green pod yield per plant and YLD= marketable green pod yield per hectare.

such as fruit yield per plant, fruit diameter and single fruit weight were among the most important yield components which had highly significant positive association with marketable green pod. Thus, selection based on these traits improves fruit yield per hectare. Generally, two years evaluation indicated that Jeju and Marecofana varieties outsmart the other varieties hence, the two varieties should further be shown to farmers in Western Tigray for them to select the best one.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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