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Evaluation of hot pepper (*Capsicum annum* L.) varieties for green pod yield and quality under rain fed production at Teppi, South Western Ethiopia

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Summary: The trials were designed with three replications in a randomized complete block design in order to evaluate the phenological, growth and yield potential of hot pepper varieties such as 'Mareko fana', 'Melka Zala', 'Melka Awaze', 'Melka Shote' and local check. Significant difference was observed between growing year and used varieties. The varieties also performed significantly different ($p<0.05$) for most of the considered traits in the study. The result revealed that varieties 'Melka Zala', 'Mareko fana' and 'Melka Awaze' were scored highest green pod yield of 8.39, 8.71 and 11.39 ton per hectare, respectively. However, 'Mareko fana' variety was susceptible to disease attack as compared to other varieties. Therefore, promoting both 'Melka Awaze' and 'Melka Zala' varieties for widespread production for Teppi and the areas with similar agro-ecological conditions could contribute to boost the productivity of hot pepper. 'Mareko fana' could also be used for dry pod purpose due to its attractive color.

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Key words: hot pepper, adaptability, Teppi, Southwestern Ethiopia

Introduction

The hot pepper (*Capsicum annum* L.) is commonly grown in Latin America and is a member of the *Solanceae* family (Rodriguez et al., 2008). It is a seasonal plant and grown as annual crop and produced for its fruits and it is economically very important vegetable crop around the globe. In Ethiopia, it has a great economic importance both for small holder farmers and export earnings (Beyene & David, 2007). It is a high value crop used as vegetable and spice crops around the world for its pungent flavor and aroma (Obidiebub et al., 2012). Because it is wide accepted in the Ethiopian diet, it is an essential traditional crop mainly used for its pungency and color (Molla et al., 2019). Hot pepper is the second most important vegetable in the world next to tomato (Berhanu et al., 2011). It is a great source of vitamins and minerals, including vitamins A, E, and C, which are essential for human health (Bosland & Votava, 2000).

Peppers are very important in fresh and processed forms along with different spices for daily consumption (Dessie & Birhanu, 2017). Pepper requires a hot and dry climate free of frost and suitable agroecological areas. The ideal altitude range for pepper production is between 1000 and 1800 metres above sea level (m.a.s.l.). During the 2017/18 cropping season, the total area farmed of pepper (green and red peppers) was 162 960.2 hectares, with a total production of 3 279 62.98 tones estimated. In Ethiopia, the total production shares of pepper, especially for red pepper is high as compared with other vegetables such as lettuce, tomatoes, head cabbage, onion and others (CSA, 2018). Of the total estimated area under vegetables, the lion share which is about 73.09% and 16.33% was under Red peppers and Ethiopian Cabbage, respectively, (CSA, 2018). The current world average productivity of green and dry pepper is 32.3 t/ha and 3.8 t/ha respectively (FAOSTAT, 2017). The average dry and green hot pepper production in Ethiopia is 1.6 and 10.7 t/ha, respectively (Abraham et al., 2016), well below the global average.

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 (Fekadu & Dendena, 2006). To overcome the aforementioned constraints, the introduction, evaluation, and selection of improved hot pepper varieties that are high yielding and disease resistant, which would help to improve crop production and productivity in the study area, is a quick approach that should be prioritized so that it contributes to alleviating major bottlenecks in the existing production system. To provide information on the productivity and quality of released hot pepper varieties for green pod, available and potential varieties must be tested for green pod yield and quality both throughout the rainy and off-seasons. To that purpose, the current study was launched to evaluate hot pepper cultivars for green pod yield, attractive fresh consumption features, and marketability.

Materials and methods

Site description

Teppi Agricultural Research Centre hosted the experiment. Teppi is located in south western Ethiopia in SNNP Reginal

State at 1200 m elevation above the sea level. The annual rainfall is 1559 mm with maximum and minimum temperatures of 29.7 ºC and 15.5 ºC, respectively. The soil type is reddish brown sandy clay loam with a pH range of 5.6 to 6.0.

Varieties

Three released varieties and one local variety which were obtained from Melkassa Agricultural Research Center and Teppi area respectively, were used for the implementation of the experiment. Experimental material and features of varieties are shown in ***Table 1***.

Experimental design and management

The experiment was carried out for three years in a row under rainfed conditions and was designed in Randomized Complete Block Design (RCBD) with three replications. The seed of the varieties was sown on the seed bed at Teppi Agricultural Research Center. After six weeks, the seedlings were transplanted at the main field. The recommended management practices for seedling management were strictly followed. The seedlings were transplanted at row and plant spacing of 70 cm and 30 cm, respectively, with 10 plants per row. The plot size was 3 m x 2.8 m = 8.4 m^2 with a total of 40 plants per plot. The spacing of 0.5 m and 1.5 m was used between plots and between blocks respectively. Field layout was done according to treatments and design. DAP was applied at the rate of 200 kg/ha before transplanting and urea at the rate of 100 kg/ha was side dressed in split application where 50% of urea was applied after 21 days of transplanting and the other 50% at one and half month after transplanting. Every standard cultural practice was followed regularly as recommended. Diseases and insect management practices was made according to the recommendations given for hot pepper production in the country. Harvesting was done when the green pods have got firm green mature pods from two middle rows. After harvest, the pods were weighed immediately before shrinking and then yield and quality data was recorded.

Data analysis

Phonological data on: days to 50% flowering, days to 50% pod setting, and growth data such as: plant height, primary branch number per plant, secondary branch number per plant, and tertiary branch number per plant. Yield and yield-related information on: the total green pod yield per plot (kg), average pod weight, pod length, and pod diameter were all measured. All collected data were summarized and subjected to analysis using SAS statistical Software. Differences among parameter values were considered significant at $p<0.05$. Means of parameters were separated using least significant difference test.

Results and discussion

Plant height (cm)

Varieties showed significant difference for plant height as indicated in ***Table 2***. The varieties 'Melka Awaze' and 'Melka Zala' had the tallest plant height (81.76 and 80.13) respectively, while 'Melka Shote' had the shortest plant height (57.78). Similar results were reported by Melkassa Agricultural Research Centre (MARC, 2005), which said that variety 'Melka Zala' had the highest plant height (62 cm) when compared to the other varieties used in the study and Sileshi et al. (2014) also stated that variety 'Melka Zala' had the tallest plant height.

Branch number per plant

As shown in (***Table 2***), there was a considerable variation in the primary branch number of different hot pepper varieties. As a result, the varieties 'Melka Shote' (8.49) and 'Melka Zala' (8.49) had the highest number of primary branches based on the combined mean of three seasons when compared to the other varieties used in the study.

Days to fifty percent flowering

The number of days to 50% flowering showed a highly significant (p0.001) difference across varieties (***Table 2***). Earliest numbers of days to reach 50% flowering was observed from variety local (54.44 days), 'Melka Awaze' (59.22 days) and 'Mareko fana' (57.56 days) even though they are statistically similar. While the longest days number to attain 50% flowering was recorded from 'Melka Zala' (69.33 days) and 'Melka Shote' (62.11 days). The difference in the 50% flowering might be related with the varietal difference, days taken before transplanting and growing environments. This conclusion is consistent with the findings of (Kahsay, 2017), who showed comparable ranges (60-72 days) for different varieties, including the cultivars used in this study. Melaku et al. (2015) reported that the variation in the days to 50% could be probably due to their genetic factor, early acclimatization to the growing area.

Number of pods per plant

The results of the analysis of variance revealed a highly significant (p0.001) difference between the varieties in terms of the number of fruits per plant (***Table 3***). 'Melka Shote' variety had the highest number of fruits (39.73) even if the size is smaller compared with the other varieties followed by Malka Awaze variety, while the least number of fruits per plant was recorded from variety 'Mareko fana' and local (22.06 and 22.73) respectively. Variations in fruit number may be followed by vegetative growth, which may lead to the production of more fruit. The result reported by Tibebu & Bizuayehu (2014) confirmed that fruit yield influenced by environmental factors like temperature and also yield related traits like canopy size that could limit the number of branches. Higher number of branches mean that, there could be a possibility for higher fruit production.

Pod length and diameter (cm)

In terms of fruit length and diameter, there was a highly significant (p0.01) difference across kinds (***Table 3***). As a result, 'Melka Zala' (11.79) had the longest fruits, followed by 'Melka Awaze' (9.78) and 'Melka Shote' (9.66). 'Mareko fana' (9.05) and local variety had the shortest lengths (9.16). 'Melka Zala' shown a considerable difference in fruit length among all varieties. The significant difference in fruit length among the hot pepper varieties could probably attributed to the inherited traits and adaptability to the environmental condition of the study area. This result corroborated the findings of Haileslassie et al. (2015) and Seleshi et al. (2014).

Table 1: Description of four hot pepper varieties with their agro-ecological adaptations.

Variety	Year of release	Maturity (days)	Dry pod yield (t/ha)	Area of Adaptation	Unique characters
'Mareko fana'	1984	110-130	1.5-2.0	Altitude 1400-1900 m.a.s.l. Temp.25-28 ºC (day) and 15-20 ºC (night)	High acceptance for local use for its brown pod color
'Melka Awaze'	2007	100-110	2.5-2.8	Altitude 1000-2200 m.a.s.l. RF: 900-1300 mm Temp.25-28 ºC (day) and 15-20 ºC (night)	Tolerant to soil borne diseases, early maturing
'Melka Shote'	2007	110-120	2.0-3.0	Altitude 1000-2200 m.a.s.l. RF:900-1300mm Temp.25-28 ºC (day) and 15-20 ºC (night)	Tolerant to soil borne diseases
'Melka Zala'	2004	130-150	1.5-2.5	Altitude 1400-1900 m.a.s.l. Temp.25-28 ºC (day) and 15-20 ºC (night)	Tolerant to soil borne diseases

Table 2. Mean phonological and growth traits as affected by different varieties.

Variety	50% flowering date	Pod setting date	Plant height (cm)	Number of primary branches	Number of secondary branches	Number of tertiary branches
'Melka Zala'	69.33^{a}	101.78^{a}	80.13^{a}	7.24^{ab}	9.89^{a}	13.33^{ab}
'Melka Shote'	62.11^{ab}	95.67^{ab}	57.78^{b}	8.49^{a}	11.66^{a}	14.82^{a}
'Melka Awaze'	59.22^{bc}	94^{b}	81.76^{a}	5.4^{c}	9.49^{a}	13.42^{ab}
'Mareko fana'	57.56^{bc}	94.44^{b}	60.96^{b}	7^{b}	9.99^{a}	10.76^{c}
Local	54.44^{c}	94.33^{b}	59.51^{b}	5.71^{c}	10.67^{a}	11.07^{bc}
CV (%)	12.52	7.84	12.2	19.19	26.62	20.88
$LSD_{(0.05)}$	7.321	7.27	8	1.25	2.658	2.56

Table 3. Mean yield components of hot pepper as affected by different varieties.

Variety	Number of pod per plant	Total green pod yield per plot (kg)	Average pod weight (gm)	Pod length (cm)	Pod diameter (cm)
'Melka Zala'	23.2^{c}	3.526^{b}	10.63^{a}	11.79^{a}	1.68^{a}
'Melka Shote'	39.73^{a}	3.33^{bc}	6.67^{d}	9.66^{b}	1.14^{c}
'Melka Awaze'	31.21^{b}	4.78^{a}	9.65^{b}	9.78^{b}	1.45^{b}
'Mareko fana'	22.06^{c}	3.66^{b}	10.94^{a}	9.05^{c}	1.79^{a}
Local	22.73^{c}	2.87^{c}	8.056^{c}	9.16^{c}	1.40^{b}
CV (%)	24.25	15.73	8.54	3.67	13.16
$LSD_{(0.05)}$	6.51	0.55	0.758	0.35	0.19

Table 4. Mean yield of hot pepper as affected by different varieties.

Variety	Yield (ton/ha) year 1	Yield (ton/ha) year 2	Yield (ton/ha) year 3	Mean yield (ton/ha)
'Melka Zala'	7.23^{b}	10.18^{b}	7.78^{ab}	8.39^{b}
'Melka Shote'	6.70^{b}	10.12^{b}	6.94^{b}	7.92^{bc}
'Melka Awaze'	10.49^{a}	14.89^{a}	8.81^{a}	11.39^{a}
'Mareko fana'	8.46^{ab}	8.89^{b}	8.77^{a}	8.71^{b}
Local	6.75^{b}	7.14^{b}	6.63^{b}	6.84^{c}
CV (%)	17.8	16.8	9.19	15.73
$LSD_{(0.05)}$	2.66	3.24	1.35	1.32

Similar findings were reported by Tibebu & Bizuayehu (2014) and Kahsay (2017). The greatest fruit diameter was recorded for the cultivar 'Mareko fana' (1.79), followed by 'Melka Zala' (1.68). The 'Melka Shote' cultivar, on the other hand, had the smallest fruit diameter (1.14). The result showed that 'Melka Zala' and 'Mareko fana' showed significant difference in fruits diameter from all other varieties. This result was in agreement with the finding of Kahsay (2017) who reported that the highest fruit diameter was recorded for 'Mareko fana' and the lowest fruit diameter was recorded for 'Melka Shote' variety. The observed difference in fruit diameter between varieties could be due to varietal differences. Haileslassie et al. (2015) discovered that varietal influence had a substantial effect on fruit diameter. Similarly, this was consistent with the findings of Tibebu & Bizuayehu (2014), as 'Mareko fana' generated the largest fruit diameter (1.98 cm). Hot peppers with larger pod sizes are appreciated for their quality, and fresh and dried pods are in high demand in Ethiopian markets (Beyene & David, 2007). The differences were most likely related to hereditary features or the growing environment.

Average fruit weight (gm)

The ANOVA results revealed that there is a significant variation in fruit weight between the varieties (***Table 3***). Accordingly, 'Melka Zala' had the highest fruit weight (10.63), followed by 'Mareko fana' (10.94), and the local variety had the lowest (8.056). In terms of average fruit weight, there was no significant difference between the 'Mareko fana' and 'Melka Zala' varieties. The different years results also showed similar trends. The findings show that both genotype and environment influence the traits. A similar outcome was reported by (Seleshi et al., 2014).

Total yield (t/ha)

The results of ANOVA showed that significant difference was observed among the varieties interms of total yield (***Table 4***). Variety 'Melka Awaze' had the highest total yield, followed by variety 'Melka Zala', while variety 'Melka Shote' and local had the lowest total yield. Among the several varieties evaluated with differing production seasons, the 'Melka Awaze' variety produced the highest green pods compared to other varieties over the test years. The combined mean green pod yield revealed that, variety 'Melka Awaze' (11.39 t/ha) followed by produced significantly high pod yield as compared to other varieties while the lowest yield was recorded for variety local (6.84 t/ha) (***Table 4***). This is associated with superior vegetative growth including height, pod length, pod diameter, average pod weight etc. The maximum green pod yield was found from the variety 'Melka Awaze', which differed significantly from the yield obtained from the other varieties. Dessie & Birhanu (2017) discovered that the variety 'Melka Awaze' produced the maximum yields in Woreta, Northwestern Ethiopia. The varieties 'Melka Awaze', 'Mareko fana', 'Melka Zala' and 'Melka Shote' had 66.52%, 27.33%, 22.66% and 15.79% yield advantage over local variety. Therefore, based on the studied traits, performance of varieties 'Melka Awaze', 'Mareko fana' and 'Melka Zala' were superior as compared to other varieties with in similar agro-climatic conditions. These varieties performed best under different production season. This indicates that these three varieties can suitably fit for the production during dry seasons and under rain fed conditions.

Conclusions

Hot pepper is regarded as one of the most profitable vegetable crops in Ethiopia and around the world. Despite this, a number of constraints, such as a lack of improved varieties, diseases, and other biotic and abiotic factors along the Hot pepper production chain, must be considered concurrently in order to improve hot pepper productivity in Ethiopia, which is still low in comparison to other countries, and to ensure higher yields, better income, and a significant contribution of hot pepper farming to improved livelihoods in the country. The study's findings demonstrated that yield and related attributes were considerably influenced by variety and growing environment. The highest yield was obtained by 'Melka Awaze' and the least yield was recorded by local variety. In general, 'Melka Awaze' and 'Melka Zala' were well performed for the production of green pod than other varieties and have to be multiplied and disseminated to users. 'Mareko fana' showed susceptibility to diseases. Despite this, it is preferable for dry pod purpose due to its attractive color. Further study should be carried out with other varieties in order to improve hot pepper production under the similar conditions of South Western Ethiopia.

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