An experiment was conducted to evaluate the performance oregano in different agro-ecology of Ethiopia for its agronomic and quality traits at Wondo Genet, Koka and Holleta for two years from 2012 to 2013. Data on plant height, leaf to stem ratio, fresh leaf yield/plant, fresh leaf yield/ha, percent essential oil (EO) content and EO yield were collected from three locations arranged in randomized complete block design with four replications. Testing location exerted a highly significant influence (P<0.01) on the performance of oregano. The overall mean performance of plant height, leaf to stem ratio, leaf yield/plant, leaf yield/ha were 39.87 cm, 2.68, 159.27 g and 8.91 t, respectively. The respective plant height, leaf to stem ratio, leaf yield/plant, leaf yield/ha of oregano across the tested location ranged from 34.93 to 39.87 cm, 1.05 to 3.33, 105.86 to 216.08 g and 5.88 to 12.01 t. The highest value of plant height was recorded at Wondo Genet; while, the lowest was obtained at Holleta. However, the highest values for leaf yield/plant and leaf yield/ha of oregano was recorded at Holleta. The respective overall mean value of EO content and EO yield tested at three locations and two years were 0.52% and 45.67 kg. The EO content and EO yield ranged from 0.37-0.79% and 23.09-69.81 kg, respectively. The highest values of these characters were obtained at Wondo Genet. The values on EO content and EO yield were consistent under both testing years. Hence, it is the location that affects the production of oregano in the country.

Key words: Aromatic Herb, Essential oil, Ethiopia, Oregano, Spice.

INTRODUCTION

Oregano (Origanum vulgare L.) is a spice, medicinal and aromatic perennial herb that belongs to the member of the Lamiaceae family and has a complex taxonomy (Derwich et al., 2010; Fatma et al., 2010). The genus Origanum includes 39 species (Kintzios, 2002) from which, only O. vulgare L. is available in Ethiopia. Oregano is native to the Mediterranean Basin (Thanos, 1995). It grows in different areas at wider ranges of ecologies (Snogerup, 1971). The climatic life zone for O. vulgare reported to be 5–28°C with an annual precipitation of 0.4–2.7 m and a range of soil pH from 4.5–8.7 is appropriate for its growth (Marzi, 1997). It is cultivated and distributed all over Europe, West and Central Asia up to Taiwan (Ietswaart, 1980). This indicates the economic significance of the crop in diversified societies and communities of the different countries.

Oregano has been a valuable source of natural products for maintaining human health for a long period of time, especially in the last decades (Force et al., 2000). Oregano plays a primary role among culinary herbs in world trade (Oliver, 1997). The use of oregano as medicinal plant is believed to be due to biological properties of $p$-cymene and carvacrol (D’Antuono et al., 2000). The fresh leaves and dried herb of oregano as
well as essential oil are used medicinally (Hammer et al., 1999). The essential oil of oregano has antifungal (Cleff et al., 2010; Ertas et al., 2005), antibacterial (Baydar et al., 2004; Viuda-Martos et al., 2008), antioxidant (Milos et al., 2000; Sahin et al., 2004; Shan et al., 2005; Wojdyla et al., 2007), antihyperglycaemic (Lembadri et al., 2004), antithrombin (Goun et al., 2002) and cytotoxic activity (Sivropoulou et al., 1996). Some authors have reported the effectiveness of oregano extracts to reduce lipid oxidation (Djiane et al., 2002; 2003; Fasseas et al., 2007; Camo et al., 2008), color loss, and microbial growth (Djiane et al., 2002; 2003; Camo et al., 2008; Zinoviadou et al., 2009) in some types of meats. Herbs and extracts of oregano have been added in a variety of foods to improve their sensory characteristics and extend shelf-life (Shahidi et al., 1992).

There are many factors that influence agronomic characteristics, biomass and essential oil yield of aromatic plants. Among these, genotype and growing conditions (Marotti et al., 1994; Beemnet and Getinet, 2010; Beemnet et al., 2011; 2013), harvesting age (Marotti et al., 1993; Beemnet et al., 2011) and spacing (Yasin et al., 2003; Khazaie et al., 2007; Al-Ramamneh 2009; Solomon and Beemnet, 2011; Beemnet et al., 2012) are primarily mentioned. In Ethiopia, there exists diverse ecological condition (NMSA, 1996; Kebebew, 2003; Andargachew, 2007). Due to the existence of diverse agro ecologies, it is a prerequisite to evaluate the performance of oregano under different locations of Ethiopia for its agronomic and chemical characters for getting optimum benefit out of the cultivation of oregano.

In Ethiopia, Wondo Genet Agricultural Research Center is conducting and coordinating a number of research and development activities about the production, processing, marketing and utilization of prioritized aromatic and medicinal plants at national level. From these priority crops, oregano is the one. Despite the crop has got diverse potential uses, no effort has been made to evaluate its performance on morpho-agronomic and chemical traits in Ethiopia. This indicates that, the current knowledge about its agronomy, variety development and biology are neither complete nor conclusive and, hence, many aspects of oregano remain unknown under Ethiopian condition before this study. Consequently, our knowledge on this potential crop is limited. This lack of information is a major hindrance to exploit this economically important spice, aromatic and medicinal herb more. To help in filling the aforementioned research and development gaps, this experiment was carried out with the objective of evaluating the performance of oregano for agronomic and chemical traits under different agro ecologies of Ethiopia.

**MATERIALS AND METHODS**

Planting material maintained at the botanic garden of Wondo Genet Agricultural Research was used for the study. The experiment was conducted in Oromia and SNNPRS regions of Ethiopia at Wondo Genet, Koka and Holleta for two years from 2012 to 2013. The ecological descriptions of the testing locations are summarized under table 1. Top cuttings having five pairs of leaves were taken from 6 months old disease free mother plants for seedling preparation. The lower two pairs of leaves were removed and planted in properly prepared soil mixtures in polyethylene bags of 10 cm diameter and 12 cm height. Seedlings were raised in the nursery for three months in polyethylene bags before being transplanted to the field experimental plots.

A spacing of 60 cm was maintained between rows and 30 cm between plants. Six rows each having six plants were maintained in the plot. No fertilizer and chemical was applied during evaluation activity. All cultural practices and watering through flooding irrigation were done as required. Harvesting was done 6 months after transplanting to the main experimental field. Harvesting was done by cutting the plant 5 cm above the ground level with the help of sickles as soon as the night dew has evaporated from the plants.

Data on plant height, leaf to stem ratio, fresh leaf yield/plant, fresh leaf yield/ha, percent EO content and EO yield were collected from four locations arranged in randomized complete block design with four replications. Percent EO content was determined on fresh weight (w/w) basis from 250g of fresh composite leaves harvested from the three middle row plants of a plot. The laboratory analysis was done at Wondo Genet Agricultural Research Center. EO was extracted by hydro distillation as illustrated by Guenther (1972).

To statically analyze the differences in agronomic and chemical characteristics caused by the growing locations and years, five samples were taken from the central rows of each plot replicated four times. Statistical analysis of experimental data was performed by analysis of variance (ANOVA) using SAS PROC GLM (2002) at P<0.05.

**Table 1. Summary of site descriptions for three testing locations in Ethiopia.**

<table>
<thead>
<tr>
<th>Testing locations</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Soil pH</th>
<th>Soil type</th>
<th>Rainfall (mm)</th>
<th>Altitude (m.a.s.l)</th>
<th>Annual average temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wondo Genet</td>
<td>7°19’2”N</td>
<td>38°38’E</td>
<td>6.4</td>
<td>sandy clay loam</td>
<td>1000</td>
<td>1876</td>
<td>12.02</td>
</tr>
<tr>
<td>Koka</td>
<td>8°26’N</td>
<td>39°1’E</td>
<td>-</td>
<td>Clay soil</td>
<td>830.9</td>
<td>1604</td>
<td>13.68</td>
</tr>
<tr>
<td>Holletta</td>
<td>9°03’N</td>
<td>38°30’E</td>
<td>5.5</td>
<td>red brown clay loam</td>
<td>1100</td>
<td>2390</td>
<td>6.13°C</td>
</tr>
</tbody>
</table>

To statistically analyze the differences in agronomic and chemical characteristics caused by the growing locations and years, five samples were taken from the central rows of each plot replicated four times. Statistical analysis of experimental data was performed by analysis of variance (ANOVA) using SAS PROC GLM (2002) at P<0.05.
**Table 2.** Mean squares from the combined analysis of variance for the different traits of oregano tested at Wondo Genet, Koka and Holleta tested during 2012 and 2013.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>Plant height</th>
<th>Leaf to stem ratio</th>
<th>Leaf yield/plant</th>
<th>Leaf yield/ha</th>
<th>EO content (%)</th>
<th>EO yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>3</td>
<td>7.23</td>
<td>0.95</td>
<td>762.1</td>
<td>2876708</td>
<td>0.0041</td>
<td>191</td>
</tr>
<tr>
<td>Location (L)</td>
<td>2</td>
<td>49.90*</td>
<td>2.59ns</td>
<td>24362.6*</td>
<td>75009809**</td>
<td>0.4452**</td>
<td>4379**</td>
</tr>
<tr>
<td>Year (Y)</td>
<td>1</td>
<td>86.26*</td>
<td>0.10ns</td>
<td>29.9ns</td>
<td>363ns</td>
<td>0.0001</td>
<td>2.66</td>
</tr>
<tr>
<td>L*Y</td>
<td>2</td>
<td>46.9ns</td>
<td>0.31ns</td>
<td>805.1ns</td>
<td>2707928ns</td>
<td>0.0028</td>
<td>69.19</td>
</tr>
<tr>
<td>Error</td>
<td>15</td>
<td>13.18</td>
<td>0.97</td>
<td>1726.13</td>
<td>5640039</td>
<td>0.0058</td>
<td>152</td>
</tr>
</tbody>
</table>

**CV** = Significant at \( P < 0.01 \) level, *= Significant at \( P < 0.05 \) level and ns=Non significant at \( P < 0.05 \) level.

**Table 3.** Some morphological characters of oregano

<table>
<thead>
<tr>
<th>Morphological Characters</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf length (cm)</td>
<td>1.7-2.8</td>
<td>2.21</td>
</tr>
<tr>
<td>Leaf width (cm)</td>
<td>1-1.50</td>
<td>1.18</td>
</tr>
<tr>
<td>Leaf to stem ratio</td>
<td>1.05-3.33</td>
<td>2.68</td>
</tr>
</tbody>
</table>

Differences between means were assessed using the least significance difference (LSD) test at \( P<0.05 \).

**RESULTS AND DISCUSSION**

**Variation in Morpho-agronomic Characteristics and Chemical Traits of Oregano**

Mean squares from combined analysis of variance for six characters of oregano tested for two years at three locations of Ethiopia are summarized in table 2. Testing year exerted a significant influence \( (P<0.05) \) on plant height. Interaction effects of location by testing year exerted a non significant influence \( (P<0.05) \) on all parameters considered in this activity indicating performance consistency of the different characters over the testing years under different locations. Location exerted a significant influence \( (P<0.05) \) on plant height and fresh leaf yield/plant, and a highly significant influence \( (P<0.01) \) on leaf yield/ha, percent EO content and EO yield. This indicates, these traits were influenced by a change in the growing environment. The significance of location effect was expected because Wondo Genet, Koka and Holleta vary in their soil type, rainfall and temperature (Table 1). In agreement to the present study, Fehr (1991) reported that every factor that is a part of the environment of a plant has the potential to cause differential performance. Likewise, Frankel et al. (1994) and IRRI (1996) reported that fluctuating features of the location such as rainfall, relative humidity, temperature, etc. are some of the environmental factors that cause performance variation in plants. The influence of location on agronomic and chemical traits of aromatic and medicinal plants were also reported Aloysia triphylla L. (Beemnet et al., 2013), Coriandrum sativum L. (Beemnet and Getinet, 2010), Cymbopogon citratus L. (Beemnet et al., 2011), Artemisia annua L. (Belay, 2007; Zewdinesh et al., 2011), Stevia rebaudiana Bertoni (Beemnet et al., 2012) and Aflatuni (2005) for Mentha arvensis L. and M. piperiata L., indicating the importance of knowing optimum growing locations before intending production of oregano in Ethiopia.

**Performance of Oregano in Morpho-agronomic and Chemical Characters**

Analysis of variance revealed that there existed a performance variation in morpho-agronomic characters (plant height, leaf to stem ratio, leaf yield/plant and leaf yield/ha) and chemical characters (percent EO content and EO yield/ha) of oregano across testing locations and years (Table 2). The overall mean and range values of morphological characters (leaf length and width) are summarized in table 3. The respective mean performances of agronomic and chemical characters of due to location effects and testing years are summarized in tables 4 and 5.

**Performance of Oregano in Morphological and Agronomic Characters in Ethiopia**

The overall mean performance of leaf length, leaf width, plant height, leaf to stem ratio, leaf yield/plant, leaf yield/ha were 2.21 cm, 1.18 cm, 37.18 cm, 2.68, 159.27 g and 8.91 t, respectively. The respective leaf length, leaf width, plant height, leaf to stem ratio, leaf yield/plant and leaf yield/ha of oregano across the tested location ranged from 1.7 to 2.8 cm, 1 to 1.50 cm, 34.93 to 39.87 cm, 1.05 to 3.33, 105.86 to 216.08 g and 5.88 to 12.01 t. The highest value of plant height was recorded at Wondo Genet; while, the lowest was obtained at Holleta.
Holleta. The performances of oregano on leaf to stem plant height, leaf yield/plant and leaf yield/ha over the testing years was reported by Dunford and Vazquez (2005) from the experiments under different water stress conditions in Argentina (Torres et al., 2011). A respective range of values from 17.31–34.24 cm, 10.59–15.11 cm and 34.50–61.00 cm was reported for 12 Oregano germplasms evaluated in Ethiopia for agronomic and chemical traits tested at Wondo Genet, Koka and Holleta during the year 2012 and 2013.

Table 4. Mean performance of oregano for its agronomic and chemical traits tested at Wondo Genet, Koka and Holleta during the year 2012 and 2013.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Plant height (cm)</th>
<th>Leaf yield/plant (g)</th>
<th>Leaf to stem ratio</th>
<th>Leaf yield/ha (kg)</th>
<th>EO content (%)</th>
<th>EO yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holleta</td>
<td>34.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>216.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12004&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.37&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.09&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Koka</td>
<td>36.75&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>105.86&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5881&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.39&lt;sup&gt;b&lt;/sup&gt;</td>
<td>44.09&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wondo Genet</td>
<td>39.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>155.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8835&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.79&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.81&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>37.18</td>
<td>159.27</td>
<td>2.68</td>
<td>8906.62</td>
<td>0.519</td>
<td>45.67</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>3.86</td>
<td>44.27</td>
<td>2.41</td>
<td>2531</td>
<td>0.08</td>
<td>13.14</td>
</tr>
</tbody>
</table>

Means followed by the same letter with in the same column are statistically non significant at P < 0.05 according to least significant difference (LSD) test.

Table 5. Mean performance of oregano for its agronomic and chemical traits tested at Wondo Genet, Koka and Holleta during the year 2012 and 2013.

<table>
<thead>
<tr>
<th>Testing years</th>
<th>Plant height (cm)</th>
<th>Leaf yield/plant (g)</th>
<th>Leaf to stem ratio</th>
<th>Leaf yield/ha (kg)</th>
<th>EO content (%)</th>
<th>EO yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>39.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>158.16&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.61&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8902.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>46.00&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2013</td>
<td>35.29&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>160.93&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8910.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.51&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mean</td>
<td>37.18</td>
<td>159.27</td>
<td>2.68</td>
<td>8906.62</td>
<td>0.519</td>
<td>45.67</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>3.15</td>
<td>36.15</td>
<td>0.85</td>
<td>2066.5</td>
<td>0.06</td>
<td>10.72</td>
</tr>
</tbody>
</table>

Means followed by the same letter with in the same column are statistically non significant at P < 0.05 according to least significant difference (LSD) test.

However, the highest values for leaf to stem ratio, leaf yield/plant and leaf yield/ha of oregano was recorded at Holleta. The performances of oregano on leaf to stem ratio, leaf yield/plant and leaf yield/ha over the testing years was found consistent except for plant height. Compared with the first testing year, a decreasing value of 9.69% plant height was measured in second year.

A relatively lower value of leaf length (10–50 mm) and leaf width (5–25 mm) was reported by Raduie and Stankeviciene (2005) during characterization activities of 14 accessions of Lithuania oregano. The current study is within the range of plant height report from 30–60 cm by (Kokkini, 1997). In agreement with the present study, a comparable range of values from 17.31–34.24 cm, 10.59–15.11 cm and 34.50–61.00 cm was reported for leaf length, leaf width and plant height for studies conducted on 144 genotypes of Iranian oregano (Andi et al., 2011). A short plant height range between 15 and 25 cm was reported by Hobincu (2012) in agrobiology study of oregano species. A lower fresh yield/plant up to 56.6 g was reported by Dunford and Vazquez (2005) from experiments under different water stress conditions in Mexico. Ahmad et al. (2008) reported a comparable plant height range from 25.45 to 55.58 cm and lower range of fresh leaf yield/ha (2.02–6.42 t/ha) for Oregano in Iran. A lower leaf yield/plant range between 50.87 and 98.89 g was reported for 12 Oregano germplasms evaluated in Argentina (Torres et al., 2012). A respective range of plant height, leaf yield/plant and leaf yield/m² from 27.8 to 62.1 cm, 40.9 to 364 g and 0.17 to 1.52 g was reported for oregano evaluated under different growth stage in Poland (Wierdak, 2009).

The variation in morpho-agronomic characters in oregano in the different reports from the current study may be due to the variation in genotype, environment, soil, climatic factors. The existence of variation in agronomic characters due to genotype/cultivar, edaphic and climatic conditions was also reported by Nidagundi and Hedge (2007) for chamomiles. In Ethiopia, variation in agronomic characters due to the variation in environmental, climatic and edaphic factors was also reported for lemon verbena (Beemnet et al., 2013), lemongrass (Beemnet et al., 2011) and coriander (Beemnet and Getinet, 2010). As the value obtained in this experiment demonstrated comparable morpho-agronomic characters with the different reports, it is possible to cultivate oregano in Ethiopian for the production of spice, aromatic and medicinal herbal leaf of oregano.

Performance of Oregano for Chemical Traits in Ethiopia

The overall mean value of EO content and EO yield tested over three locations and two years were 0.52% and 45.67 kg. The EO content and EO yield ranged from 0.37–0.79% and 23.09–69.81 kg, respectively. The highest values of these characters were obtained at
Wondo Gent. The values on EO content and EO yield were consistent under both testing years. Hence, it is the location that affects the production of oregano in the country. In agreement with the present study, a comparable value of EO content range from 0.36 to 0.52% was reported by Raduine and Stankeviciene (2005) for accessions of Lithuania oregano. Shiyan et al. (2012) also reported comparable EO content range between 0.3 and 0.5% for samples taken under different developmental stage of oregano in Jordan. Likewise, comparable EO content ranging between 0.21 and 0.6% with the present study was reported for oregano evaluated under different growth stage in Poland (Wierdak, 2009). A wide range of EO content from 0.1 to 3.42% was reported by Elezi et al. (2013) for experiment conducted on 62 accessions of oregano in Albania. Similarly, wider EO content range between 0.35 and 2.36 was also reported for 12 Oregano germplasms evaluated in Argentina (Torres et al., 2012). Higher values of EO content varying from 0.7 to 2.5% (w/w) was reported for oregano plants evaluated under controlled environments (Dunford and Vazquez, 2005). The different variations of EO in oregano were reported by numerous researches (Marzi et al., 1992; Falconieri, 2011). The differences in these reports from our results may be associated with the variances in these factors, including genetic, seasonal, temperature, mois-ture, soil, day length changes on EO production and quality (Farooqi et al., 1999; Ceylan et al., 2003; Baydar et al., 2004; Yaldiz et al., 2005). Similarly, Fahmy (1955) and Langston and Leopold (1954) mentioned that climatic factors such as temperature, day length, humidity and rainfall, affected oil content of aromatic plants.

CONCLUSION

Generally, the available Oregano cultivar was found adapted well in all the test locations for all morphological, agronomic traits and chemical traits. Similarly, the values obtained in this experiment demonstrated comparable and even higher values in morpho-agronomic and chemical characters with the different reports. Hence, it is possible to use the existing oregano cultivar for the production of herbal, aromatic, spice and medicinal leaves and essential oil in Ethiopia.

ACKNOWLEDGMENT

We would like to acknowledge Wondo Genet Agricultural Research Center and Aromatic and Medicinal Plants Research Project for providing all the necessary facilities and support during the entire experimentation. Our acknowledgement also to Mr. Wondimu Manebo, Mr. Birara Tilahun, Mr. Yigermal Mola and Mr. Damtew Tsegaye of technical research assistant who collect all necessary data from all experimental fields during experimentation time and also we want to acknowledge Mr. Zerihun Jomba of laboratory technician who extracts essential oil of the plant and collect all laboratory data.

REFERENCES


Vuila-Martos, M., Ruiz-Najayas, Y., Fernandez-Lopez, J. and Angel...


