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Growing spearmint, thyme, oregano, and rosemary in Northern Wyoming using plastic tunnels

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ABSTRACT

Growing perennial herbs in a northern climate such as Northern Wyoming is a challenge. Due to short frost-free period, high wind, and inclement weather it is impossible to harvest any herbs twice a year (summer and late fall) without using any form of season extension methods. Hence, an experiment was set up to test the feasibility of season extension methods on quantitative and qualitative production of spearmint (*Mentha spicata* L.), thyme (*Thymus vulgaris* L.), Greek oregano (*Origanum vulgare* subsp. *hirtum*), and rosemary (*Rosmarinus officinalis* L.). The following season extension methods were tested: high tunnel (Ht), low tunnel (Lt), and low tunnel within high tunnel (LtHt). Except for rosemary, the herbage production of the studied herbs in LtHt was significantly higher than the herbage production in Lt and in Ht in the second harvest (late fall); rosemary died before the second harvest. The essential oil content of the herbs from this study did not vary significantly between the season extension methods. Gamma-terpinene concentration of thyme essential oil was significantly higher in LtHt than Lt and Ht in the second harvest. In oregano, the major essential oil constituent carvacrol was modestly higher in LtHt than Lt and Ht in the both harvests, while another major constituent *p*-cymene was significantly lower in LtHt than Lt in the first harvest. The chemical composition of spearmint essential oil was not affected by the different season extension methods in this study. Oxygen Radical Absorbance Capacity (ORAC) determined the antioxidant capacity of herbs. The ORAC value for oregano in LtHt were significantly higher than the same herb grown in Ht and Lt in the second harvest. Similarly, thyme had significantly higher ORAC value in LtHt than Lt in the second harvest. This study demonstrated that LtHt can provide optimal conditions for spearmint, thyme, and oregano fresh herbage and essential oil production in northern climates, even when the temperature falls below the freezing point in late fall. LtHt can also improve the antioxidant capacity of thyme and oregano.

1. Introduction

Essential oils are lipophilic substances produced by aromatic plants and herbs. Essential oils have diverse applications in various industries such as pharmaceutical, food and cosmetic industries (Baris et al., 2006; Capecka et al., 2005; Schnaublet, 2005). Medicinal and culinary herbs have a wide ecological adaptation and have been used by humans for thousands of years in many parts of the world. However, there are many places in the world where growing perennial herbs is dubious because of unfavorable growing conditions. According to the National Agricultural Statistics Service (2015), the state of Wyoming does not produce herbs, although there are several small companies producing a few herbs and medicinal plants. In recent years, Wyoming growers have expressed interest in the production of high-value herbs and essential oil crops (Zheljazkov et al., 2012). Wyoming has a limited crop growing season which is characterized by a short frost-free period (120–125 days) and because of the high elevation (940 m to

Abbreviations: LtHt, Low tunnel within high tunnel; Ht, High tunnel; Lt, Low tunnel.

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4507 m), the climate in Wyoming is relatively cool (Shiwakoti et al., 2015; Zheljazkov et al., 2012). Because of these environmental conditions, cultivating perennial herbs beyond summer is a challenge for Wyoming farmers.

Growing herbs in greenhouses could mitigate the adverse growing conditions beyond the short summer season. However, constructing and maintaining greenhouse is costly for most of the farmers. A solution to this barrier is the construction of plastic tunnels (high tunnels, and low tunnels) which are relatively inexpensive and simple to construct and maintain compared with greenhouses. High tunnels (HT) and low tunnels (Lt) have become a significant feature in intensive horticultural production systems around the world as means for extension of the growing season of crops (Jensen, 2000). These plastic tunnels provide supplemental heat, protection from the wind and maintain humidity (Lodhi et al., 2013). During the cold season when the crop needs protection from low temperature and subsequent frost, Ht and Lt are necessary for the higher productivity of the crops (Lamarre et al., 1996). High tunnel (Ht) and Lt facilitate the entrapment of carbon dioxide and enhance the photosynthetic activity of the plants and crop yield (Lodhi et al., 2013). Researchers have already demonstrated successful and high quality produce of cut flowers (Upson, 1998), tomato (Jett, 2004), strawberry (Kadir et al., 2006), stevia (Moraes et al., 2013), lettuce (Rader and Karlsson, 2006), spinach (Hecher et al., 2014) in plastic culture production of crops.

The growing season of several herbs in colder climates could possibly be extended from August to December by the use of plastic tunnels. The ability to produce herbs in the off-season offer an economic advantage for fresh market growers. Such an extended season has the ability to triple/quadruple the income from production area due to premium prices during months when locally produced herbs are not available (Adam, 2005; Morgan, 1994). Hecher et al. (2014) reported that crops could be grown in high altitude locations using diverse high tunnels methods. Hence, it was hypothesized that the beneficial properties of high tunnels and low tunnels could also be effective under the conditions of Northern Wyoming. However, it is unclear whether the synthesis and the accumulation of plant essential oils and other bioactives would be affected when herbs are grown under plastic cover. Environmental factors such as light, humidity, genetics, hormones, nutrition can affect the syntheses of plant secondary metabolites, such as essential oils (Chrysargyris et al., 2016; Miliauskas et al., 2004; Strack, 1997; Thompson et al., 2009). No previous research has reported the effect of different types of plastic tunnel systems on the chemical composition of herbs and as means of extending the growing season for herb production in Wyoming. Successful demonstration and broader use of season extension in Wyoming could therefore, open new opportunities for specialty crop production in this and other regions with a similar climate.

Fig. 1. Experiment area. The arrows in black, blue, and orange color indicate the herbs production under low tunnels, high tunnels and low tunnel within high tunnels, respectively. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

The objectives of this study were to: 1) compare herbage yield, essential oil yield and composition, and antioxidant capacity of four herbs grown under three different season extension methods, and 2) determine whether growing herbs in late fall in Northern Wyoming is feasible. The four herbs were Greek oregano (*Origanum vulgare* subsp. *hirtum* L.), spearmint (*Mentha spicata* L.), thyme (*Thymus vulgaris* L.), and rosemary (*Rosmarinus officinalis* L.). These four herbs were selected based on their high popularity with customers for their extensive use as culinary herbs, and due to their relatively high resiliency to adverse conditions.

2. Materials and methods

2.1. Field preparation and tunnel establishment

The field experiment was conducted for two seasons of 2014 (summer and late fall) at the Sheridan Research and Extension Center (ShREC), Sheridan, Wyoming (lat. 44°45.686′ N, long. 106°55.479′ W, elevation 1170 m above sea level). According to Köppen climate classification, Sheridan is classified as a semi-arid zone with hot summer and cool winter (Peel et al., 2007). The experimental site had a Wyarno clay loam soil (US Salinity Laboratory Staff, 1954) with a low slope (0–3%) and alkaline condition. Previously, the experimental site has been under turf grass for 5 years. The turf was burned down with a glyphosate and then the site was plowed at 25 cm depth in the fall of 2011, followed by disking and harrowing to break down the soil clumps and smooth the surface in the spring. Low beds (12 cm high, 91 cm wide and 21 m long) were prepared by a press-pan-type bed-shaper machine. The same machine was used to place black plastic mulches and drip-tape irrigation tubes (with emitters at every 30 cm) at around 3 cm depth in soil along the center of each bed.

ClearSpan™ Economy Round Style High Tunnel materials were purchased from FarmTek (Dyersville, IA). The high tunnel was constructed according to the guidelines provided by FarmTek. The rafters were spaced at 1.8 m intervals. The width, height, and length of the high tunnel were 6 m, 3.6 m, and 22 m, respectively. Low tunnels were prepared using 1.54 m width, 92% light transmission Sun Master® Pull and Cut Greenhouse Film and Galvanized Premium Row Cover Hoops (1.89 m wide × 0.91 m high) purchased from Growers Supply, Dyersville, Iowa. Four raised beds were prepared inside the high tunnel (Ht), and two raised beds were prepared outside the Ht. Each raised bed was divided into subplots; subplots were 1.5 m long and 0.91 m wide. The three different extended season production systems compared in this experiment were (i) high tunnel (Ht), (ii) low tunnel (Lt), and (iii) low tunnel within high tunnel (LtHt) (Fig. 1).

2.2. Experimental methods

Among the four beds inside the Ht, two beds were in Lt i.e., low tunnel within high tunnel (LtHt). The two beds outside the Ht were in Lt only. Therefore, the treatments of the experiment were LtHt, Lt, and Ht with completely randomized design (CRD). The picture of the experimental site and setup is shown in Fig. 1. Each bed of each treatment was divided into 10 subplots, with 10 plants per subplot with a spacing of 0.4 m between the subplots. Among the 10 crops, five were herbs and five were vegetables (the results from the vegetables are reported in another manuscript). Later this experiment had to be continued with 4 herbs as the dill (*Anethum graveolens* L.) outsized the height of the low tunnel. In this paper, results from the four herbs are reported: Greek oregano, native spearmint, thyme, and rosemary. Certified seeds of oregano and