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Influence of nutrition and water stress in *Hyptis suaveolens*

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ABSTRACT

Hyptis suaveolens (L.) Poit. is a medicinal plant that produces essential oil with high therapeutic potential, but its essential oil production is still low and it may vary according to growing conditions. The objective was to evaluate the effect of water stress and fertilization on the production of biomass and essential oil of *H. suaveolens* (L.) Poit. In factorial experiment (3 × 3), with eight replicates, *H. suaveolens* were grown in three substrates: natural soil (NS) without fertilization, NS + NPK, and NS + Poultry manure (PM), at three levels of pot capacity (PC) (field capacity for soil in pots): 100, 50, and 25% PC. At 30 days after planting, the variables were evaluated: shoots and root dry matter, root/shoots ratio, plant height, stem diameter, relative water content in the plant, chlorophylls, protein, proline, carbohydrates, content of nutrients: N, P, K, and Na^+ in plant tissue, oil yield and translocation factor. Cultivation in NS + PM improved plant growth at the water availability levels of 100 and 50% PC, except root dry matter, whose best result was obtained in NS + NPK. The contents of all biochemical variables increased due to organic fertilization, proline and carbohydrates, when plants were grown in soil under water regime of 25% PC. The substrates NS + NPK and NS + PM increased the contents of N, P, and K. The Na^+ contents were high and accumulated in the roots of plants grown with poultry manure, regardless of the studied water conditions. The best oil yield was promoted by PM fertilization. *Hyptis suaveolens* developed under good conditions of water and fertilization. Under water and salt stress conditions there was reduction of growth, osmotic adjustment and Na^+ storage in the root. Oil production was favored by fertilization, but it is still low compared with the literature.

1. Introduction

Medicinal plants have long been used by humans as a valuable natural resource. The use of phytotherapy in the treatment of diseases has aroused the interest of the scientific community in conducting studies that particularly aim to increase the yield of medicinal plants, without compromising their active principles. However, there is a concern to promote rational use of medicinal plants, taking into consideration the traditional medical practices and scientific rigor in health care (Silva, 2010).

Studies focusing on agronomic conservation and management of many species become necessary because of the scarce information on the cultivation of medicinal plants in the literature. Nevertheless, it has been known that biomass production and synthesis of active principles in medicinal plants depend on various factors, such as genetic and environmental, including biotic and abiotic stresses (Sales et al., 2009).

Water and nutrients have direct influence on the quality and quantity of bioactive constituents produced by medicinal plants (Mapeli et al., 2005), so that adequate water conditions ensure normal vegetative development (Meira et al., 2013), guaranteeing the production at satisfactory levels of the main active principles contained in plant structures. In this context, studies seeking species that guarantee a good development with low cost of water, without compromising production and yield in medicinal plants, are of extreme importance (Maia et al., 2008; Meira et al., 2013). Nutritional support has also been one of the main factors responsible for the increase of yield in plants (Maia et al., 2008) and organic fertilization, besides providing nutrients, promotes benefits in the physical and chemical structure of the soil (Rosal et al., 2011).

The Lamiaceae family includes approximately 258 genera and 7193 species, 40% of which have aromatic properties (Malendo et al., 2003). Among the genera, Hyptis stands out for being rich in species with great

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Table 1
Physical-chemical characteristics of the samples of the growing substrates at the beginning and after the experiment. Mossoró, Brazil, 2015.

Properties	Initial substrate			Final substrate		
	Natural soil	Natural soil + NPK	Natural soil + Poultry manure	Natural Soil	Natural soil + NPK	Natural soil + Poultry manure
Silty (g kg^{-1})	138.5	107.5	78	–	–	–
Clay (g kg^{-1})	37.3	29.7	18	–	–	–
Sand (g kg^{-1})	824	861.5	903	–	–	–
AD (g cm^3)	1.53	1.56	1.48	–	–	–
TDS (ppt)	74.8	88.0	232	–	–	–
pH (H_2O)	5.30	5.50	8.20	5.70	6.00	7.60
OM (g kg^{-1})	15.98	16.20	18.61	–	–	–
N (g kg^{-1})	0.63	0.77	0.63	1.05	1.26	1.68
P (mg/dm^3)	37.4	11.5	378.5	2.4	23.7	370.5
K^+ (mg/dm^3)	156.9	130.6	3642.6	296.5	680.0	103.3
Na^+ (mg/dm^3)	91.9	60.5	1192.4	30.3	434.4	208.0
Ca^{2+} ($cmolc/dm^3$)	3.70	3.70	2.50	3.00	2.80	6.50
Mg^{2+} ($cmolc/dm^3$)	2.10	2.10	3.20	1.10	1.20	1.90
Al^{3+} ($cmolc/dm^3$)	0.05	0.05	0.00	0.05	0.00	0.00
H + Al ($cmolc/dm^3$)	1.16	1.32	0.00	2.15	2.15	0.00
SB ($cmolc/dm^3$)	6.60	6.40	20.20	4.99	7.63	9.57
t ($cmolc/dm^3$)	6.65	6.45	20.20	5.04	7.63	9.57
CEC	7.76	7.72	20.20	7.14	9.77	9.57
V (%)	85	83	100	7.0	78	100
m (%)	1	1	0	1	0	0
ESP (%)	5	3	26	2	19	9

AD = Apparently density; TDS = Total dissolved solids; pH (H_2O) = Potential of hydrogen in water; OM = Organic matter; N = Nitrogenium; P = Phosphorus; K^+ = Potassium; Na^+ = Sodium; Ca^{2+} = Calcium; Mg^{2+} = Magnesium; Al^{3+} = Aluminium; H + Al = Potential acidity; SB = Sum of bases; t = Effective CEC; CEC = Cation exchange capacity; V = Base Saturation; m = Saturation by aluminum; ESP = Exchangeable sodium percentage.

economic and ethnopharmacological importance (Falcão and Menezes, 2003). *Hyptis suaveolens* (L.) Poit. is an annual species that produces essential oil rich in mono and sesquiterpenes (Martins et al., 2006). It is commonly known as 'bamburral', 'erva-canudo', 'sambacoité', 'alfazema-brava', 'alfazema-de-caboclo', 'salva-limão', and 'alfavacão' (Lorenzi and Mattos, 2002). This species has been widely studied due to its essential oil, which has high antifungal, antibacterial, anticarcinogenic and antiseptic activity (Malele et al., 2003; Moreira et al., 2010), besides exhibiting nematicidal and larvicidal activity, due to the presence of D-limonene and menthol (Falcão and Menezes, 2003). In popular medicine, it has been used as antitussive, diaphoretic, antispasmodic and is useful in the treatment of gout (Corrêa and Penna, 1984). It has also been a promising alternative in the combat against larvae and mosquitoes of Aedes albopictus and Aedes aegypti (Noegroho and Srimulyani, 1997; Conti et al., 2012). Studies by Benelli et al. (2012) confirmed the activity of essential oil of *H. suaveolens* in adults of the barn weevil Sitophilus granarius, due to the presence of the constituents sabinene, β-caryophyllene, 4-terpineol and trans-α-bergamotol. This same study, together with works by Conti et al. (2011, 2012) registered average variations in the major constituents of the oil, even though they maintained the same cultivation conditions, such changes were justified by the climatic variation.

It is well acknowledged that the *H. suaveolens* EO chemical composition and biological activity change as a function of the origin and collecting period of the plants (Tchoumbougang et al., 2005). This is a common feature among secondary metabolites and from essential oils of Lamiaceae plants in particular. Several authors reported a large variability in the chemical compounds of this family due to genetic, geographical and seasonal factors (Baydar et al., 2004; Tonzibo et al., 2009; Kodakandla et al., 2012; Bachheti et al., 2015). In general, there is little information available, from the agronomic perspective that demonstrates the behavior of medicinal, aromatic and condiment plants when subjected to agricultural production techniques (Pravuschi et al., 2010). For *H. suaveolens*, it becomes important to study fertilization as a function of water conditions, because this species is highly susceptible to the influences of the surrounding environment, and the chemical constituents of its essential oil can increase, decrease or even change the composition according to the environmental conditions. Therefore, agronomic studies become necessary, aiming to increment biomass and, consequently, the production of essential oil, whose active constituents are important from the pharmacological point of view (Maia et al., 2008; Vijay et al., 2011).

Considering the adaptation capacity of this species to semi-arid conditions, low essential oil yield and lack of information on its nutritional aspects, it becomes relevant to investigate the influence of these factors on biomass production and essential oil content. Thus, this study aimed to evaluate the effect of water stress and fertilization on the production of biomass and essential oil of *H. suaveolens* (L.) Poit.

2. Material and methods

The study was carried out at the Universidade do Estado do Rio Grande do Norte – UERN, from February to March 2015, in a greenhouse, protected with white shade cloth that attenuates 30% of solar radiation. During the experimental period, the average temperature in the greenhouse was 35.5 °C and relative air humidity was 69.4%. The soil used in the experiment was collected in the same site of occurrence of the studied species, close to the UERN (05°12′ 10S and 37°18′ 57W) in the municipality of Mossoró, Brazil. The soil was sampled in the superficial layer, at depth of 0.02 m, and classified as Quartzipsamments.

The experiment was set in completely randomized design, in a 3 × 3 factorial scheme, with three types of substrate and three levels of pot capacity (PC), totaling 9 treatments with eight replicates each and one plant per plot. The treatments consisted of three growing substrates: Natural soil (NS); NS + mineral fertilization (NPK) and NS + poultry manure (PM), and three levels of water availability: 100, 50, and 25% of PC. Poultry manure came from an egg-laying chicken farm, located in the municipality of Mossoró, and was aged for 90 days, dried, sieved and mixed to the soil. After prepared, the substrates were characterized regarding physical and chemical aspects, according to Embrapa (Silva, 2009). (Table 1).

Plants in the experiment came from seeds cultivated in polyethylene containers with capacity for 250 mL, containing NS as substrate. At 20 days after planting, *H. suaveolens* seedlings were transplanted to pots with capacity for 8 L containing the respective substrates. After