EFFECTS OF NITROGEN, PHOSPHORUS AND WATERING REGIMES ON GROWTH, LEAF YIELD AND ESSENTIAL OILS OF SAGE
(Salvia officinalis L.)

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DECLARATION AND RECOMMENDATION

Declaration
This Thesis is my original work and has not been presented for examination in any other university/institution.

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DEDICATION

This work is first dedicated to the Almighty God for his goodness, mercies and favour along this journey. Secondly, I dedicate this work to my late grandmother, Roda Nyosubo Wankyo, my late mother Rebecca Otaigo Marwa and to my beloved father Lameck Rioba Wankyo. I will never forget all the effort you put into my life.
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ABSTRACT

Sage (*Salvia officinalis* L.) belongs to Lamiaceae family. It is well known as a common medicinal and aromatic plant widely used in food as well as herbal medicine products. It has wide applications in food flavouring, cosmetics and perfumery by the use of its essential oil. In Kenya, it is increasingly becoming important mostly being grown by export farms. Its leaf productivity is however often limited by nitrogen and phosphorus, which are deficient in many Kenyan soils. The problem is even exacerbated by irregular rainfall in most parts of the country where it is grown, thus necessitating irrigation. The main objective of this study was therefore to determine the effects of nitrogen (N), phosphorus (P) and watering regimes on vegetative and leaf yield and essential oil of sage. The experiment was conducted at the Horticultural Research and Teaching Farm of Egerton University, laid out in a three factor Split Block, arrangement, in a Randomised Complete Block Design (RCBD, with three replications. Treatments consisted of N supplied as urea (46% N) at four rates; 0, 40, 80 and 120kg N/ha while P was supplied as Triple Superphosphate (46% P₂O₅) at four rates; 0, 30, 60 and 90 kg P/ha. Watering regimes included W1= Watering to field capacity once after every week, W2= Watering to field capacity once after every two weeks, and W3= watering to field capacity once after every four weeks. N was assigned to the main plots; watering to the strip plots, and P to the sub-sub plots. The study was conducted in four experiments; experiment 1 (June 2011-October 2011), experiment 2 (October 2011-February 2012) experiment 3 (March 2012-May 2012) and experiment 4 (March 2014-July 2014). Data were collected on plant height, primary and secondary branches/plant, number of internodes/plant, Leaf Area Index (LAI), Specific Leaf Weight (SLW), Leaf Fresh Weight (LFW) and Leaf Dry Weights (LDW), Total Phenolic Compounds (TPC) (Experiment 3 only), essential oil yield (Experiment 3 and 4 only) and essential oil composition (Experiment 3 only). All data were subjected to Analysis of Variance (ANOVA) and where F test was significant; treatment means were separated using the Duncan Multiple Range Test (DMRT) at P ≤ 0.05.

Results that sage responded indicated to N and P application at 80 kg N/ha and 60 kg P/ha. The growth and leaf yield parameters were maximum when these treatments were combined with watering once after every two weeks. Lower and higher N and P application rates as well as too close or far apart watering intervals reduced growth and leaf fresh and dry weights. N, watering and P regimes did not significantly influence the total phenolic compounds. The mean effects of N, P and watering frequency did affect essential oil content of the crop. Furthermore, interactive effects between these variables affected the composition of the oil. Specifically, (i) the percentage-Pinene increased with β increasing N levels, (ii) β-Pinene decreased with reducing irrigation frequency, (iii) interactive effects of N and P treatments were identified for- and contents-thujones, βof-thujone and both accumulation (iv) α was also affected by the interaction of watering regime and P application. Camphor was the major ingredient under all treatments and its percentage in the oil was higher than the recommended threshold by ISO standard (ISO, 9909). Based on the results of this study, N and P application at 80 kg N/ha and 60 kg P/ha is sufficient enough to support sage growth and leaf fresh yield, under watering once after two weeks- and regime-thujones βcan whereas maximized by application of 40 kg N/ha and 60 kg P/ha and watering once a week. There is also need to develop agrotechnical practices aimed at reducing the levels of camphor in sage growing in Kenya to conform to the recommended standards (ISO, 9909). More so, there is need for economic evaluation of these practices before they can be recommended for use in Kenya.
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