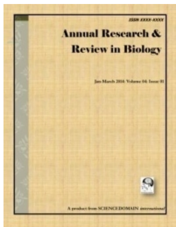

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Nutrition Assessment of N-P-K in Mint (*Mentha spicata* L.) Cultivated in Soilless System

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CRJR and AOR designed the study, wrote the protocol, collected data, supervised its execution and wrote the first draft of the manuscript. Author JAAC performed the statistical analysis and managed the analyses of the study. Authors RBM and BGAR managed the literature searches and helped revising the manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: The objective of this study was to determine the nutrient removal of N, P and K in the biomass production of mint plants at the harvest time.
Study Design: A randomized complete block experimental design with five replicates and a time series arrangement was used. Data were adjusted by polynomial regression models with SAS statistical analysis system.
Place and Duration of Study: The experiment was set up in a shade house (35% shade) located in Xalisco, Nayarit in western Mexico during the spring-summer of 2011, using a commercial variety of mint.
Methodology: The harvest days were 20, 40, 60, 80, 100 and 120 days after transplant (DAT), dates on which shoots 15 cm in length, the required size in the international market, were obtained. Steiner solution was used at five concentration levels: 25, 50, 75, 100 and 125%. The growth medium was volcanic slag with 0.3-1 cm granulometry. Plant height, fresh and dry plant biomass and stem diameter were assessed at each sampling date. Nutrient removal of nitrogen, phosphorus and potassium was determined in the different samples in order to understand the absorption dynamics of these elements under commercial management.

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Results: The results showed that the 100% nutrient solution (NS) concentration increased plant height (PH) by 34% during the first five cuts. Stem diameter (SD) had no significant differences among treatments. Above-ground fresh biomass (AGFB) and above-ground dry biomass (AGDB) were greater in the 100% NS treatment. Nitrogen, P and K ($mgkg^{-1}$) removal was dependent on the ionic concentration of the nutrient solution.
Conclusion: The concentration of the nutrient solution modified fresh and dry biomass production in mint plants. The concentration of the nutrient solution must be increased for optimal yield.

Keywords: Biomass; concentration; nutrient demand; removal; yield.

1. INTRODUCTION

Mint (*Mentha spicata* L.) a perennial plant that belongs to the Lamiaceae family, is distributed in temperate and sub-temperate regions [1]. Mint is an important crop which produces fresh or dry leaves, and essential oil. Fresh and dry leaves are used for herbal teas. Essential oil is obtained from the whole herbage and is used in the food, cosmetics, nutraceutical and pharmaceutical products [1,2].

In Mexico, production of aromatic herbs for fresh exports has grown significantly in recent years; for export, it must meet quality standards that must be managed from production. The main agronomic factors that modify mint crop production are watering and fertilizer application [3,4]. Mineral nutrients are essential for plant growth and production of essential oils in *Mentha* [5]. The published results reveal that mint requires approximately 180 kg N ha^{-1} to support optimum growth. Phosphorus removed with harvest ranges from 40 to 80 kg P_2O_5 ha^{-1}, and remove over 275 Kg K_2O ha^{-1} [6].

The nutrients can be supplied through hydroponic nutrient solutions enabling rapid growth and biomass production [7]. The majority of hydroponics research conducted in Mexico is related to the nutritional needs of vegetables and ornamental plants [8]. In this context, there is little information on crop nutrition and fertilization management of aromatic plants [9,7] growing in soilless system. Hence, it is important to develop appropriate methodologies that allow a rational use of fertilizers, which results in applying optimal doses to achieve maximum production. However, dry matter accumulation depends on the specific crop management goal when they are for fresh consumption; cuts are made every six weeks [9], if it is for dry leaves, plants are harvested when the flower buds are formed and if it is for essential oil production, not until they are in full bloom [10]. Therefore, the objective of this study was to determine the nutrient removal of N, P and K in the biomass production of mint plants at the harvest time.

2. MATERIALS AND METHODS

2.1 Study Site

The research was carried out in a tunnel-type shade house in the academic agricultural unit of the Universidad Autonoma de Nayarit at Xalisco, Mexico located at 21° 25' N and 104° 53' W. During the cultivation period, a maximum temperature of 35°C and a low of 14°C were recorded, along with 71% RH and 222 W/m^2 solar irradiance.

2.2 Growing Conditions

The plants used were obtained from *Mentha spicata* L. stolons, which were placed in 200-cavity polystyrene containers to take root. Plants were irrigated daily and kept under protected conditions for 30 days. Transplantation at the experimental site was made in flexible black polythene bags (20 X 20 cm), which contained volcanic slag with 0.3-1.0 cm granulometry.

2.3 Experimental Design

A randomized complete block experimental design with five replicates and a time series arrangement was used, and the experimental unit was 5 plants. The factors were days after transplant (DAT) (20, 40, 60, 80, 100 and 120), which corresponded to the days when the plant reached commercial size (≥ 15 cm), and five concentrations (25, 50, 75, 100 and 125%) of Universal nutrient solution [11]. The complete nutrient solution has the following concentration in meq L^{-1}: NO_3^- (12), $H_2PO_4^-$ (1), SO_4^- (7), K^+ (7), Ca^{+2} (9) and Mg^{+2} (4). The pH of the nutrient solution was adjusted between 5.5 to 6.5 and EC between 1.5 and 2.0 dS m^{-1}, whose level determines the availability of nutrients as well as influencing plant growth.

2.4 Evaluated Variables

At each sampling date, were measured plant height in cm (PH) using a rule of 60 cm and stem diameter in mm (SD), obtained with a digital vernier caliper. Additionally, the above-ground fresh weight (AGFW) was recorded after cutting the commercial-size part at about 5 cm above the surface of the substrate to allow the plant to regenerate. The material was dried in an oven at 70ºC until reaching constant weight, in order to record above-ground dry weight (AGDW). Determination of total nitrogen concentration was obtained using the Micro-Kjeldahl method described by [12]. The nutrients P and Kwere extracted by acid digestion. P was determined using an HACH spectrometer at a wavelength of 470 nm and the ammonium molybdate method [12]. For K, the flamometry method was used according to the findings by [13].

2.5 Statistical Analysis

The experimental data were analyzed in time series and the treatment means at each cutting date were adjusted by polynomial regression models with SAS statistical analysis system [14].

3. RESULTS AND DISCUSSION

3.1 Growth

At 20 and 40 DAT, the plants had not yet reached the minimum size desired for commercial production (15 cm); however, the first two samplings were performed in order to determine the nutrient removal of the mint during the establishment and development stage of the root system. From 60 DAT, commercial-size stems could be obtained, with the 75, 100 and 125 % concentrations favoring their development (Fig. 1), and an average height of 25.5 cm $plant^{-1}$ was obtained in the last four samplings.

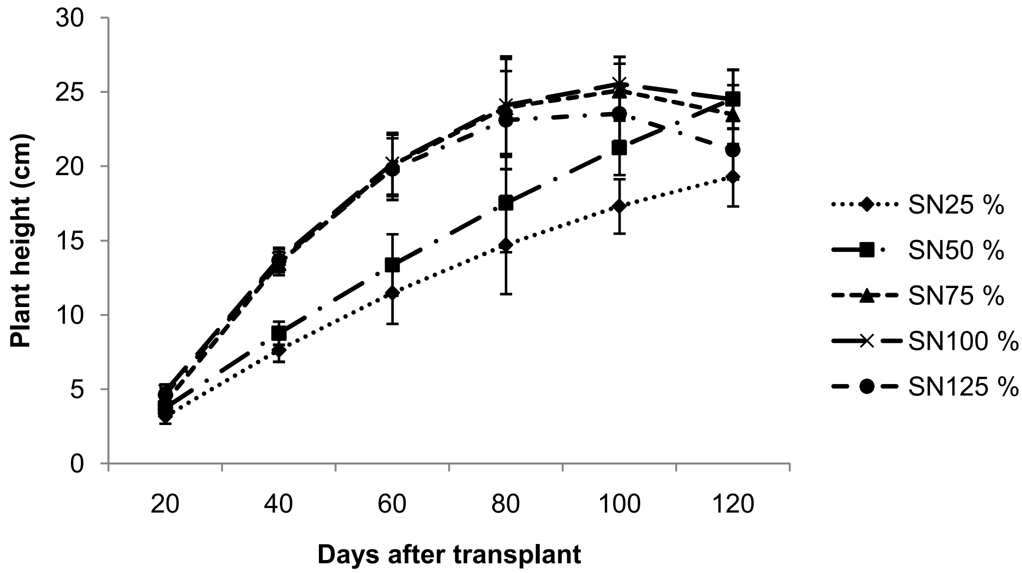


Fig. 1. Plant height (cm) in commercial size (≥ 15 cm) *M. spicata* L., based on the average values of the sampled plants

Plant regrowth after cutting was very fast compared with that reported by [9] who made cuts every nine weeks in crops grown under field conditions and obtained an average height of 32.75 cm plant^{-1}. With respect to stem diameter, no significant differences were found, which is why data are not displayed. A rapid shoot and root growth during the growing season can strain the nutrient supply and limit growth if adequate nutrient supplies are not present [6].

Above-ground fresh biomass production showed highly significant differences from 60 days after transplant among treatments, where the 25% NS treatment had the lowest accumulation of fresh weight, probably due to the low P supply in the nutrient solution (0.25 meq L^{-1}). In the 100 and 125 % NS treatments, fresh weights of 29.16 and 27.75 g plant^{-1}, respectively, were obtained. These weights are higher than those reported by [9], who obtained a weight of 21.49 g plant^{-1} as the maximum in mint grown in field conditions.

From 80 to 120 days after transplant, the treatment that accumulated the highest fresh weight was the 100% concentration, indicating that this treatment favored the growth of the above-ground part of the mint (Fig. 2). In this regard, [3] noted that nitrogen application and cultivation period significantly affect fresh and dry biomass yield, since nitrogen nutrition favored stem growth. When N supplies are limited, plant biomass and oil yield are reduced [6].

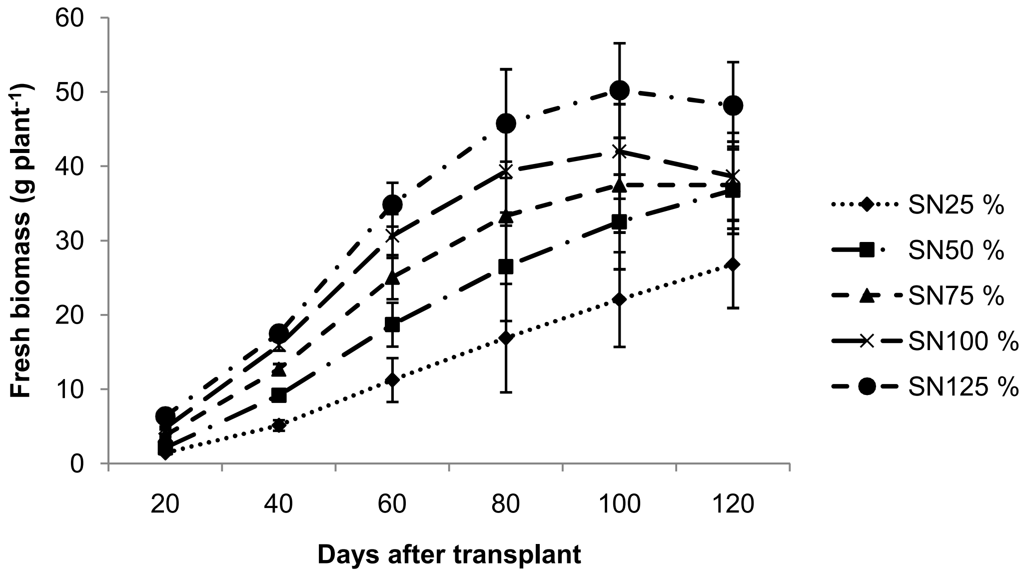


Fig. 2. Accumulation of fresh weight (g plant^{-1}) in commercial size (≥ 15 cm) *M. spicata* L. grown in substrate

The above-ground dry matter yield (Fig. 3) had a similar trend, because the amount of fresh matter determines the final dry matter yield. In this sense, plant age has a positive influence on the dry matter yield obtained. In the last sampling, there was a decrease in biomass production which could be due to an effect of plant development and age as indicated by [15].

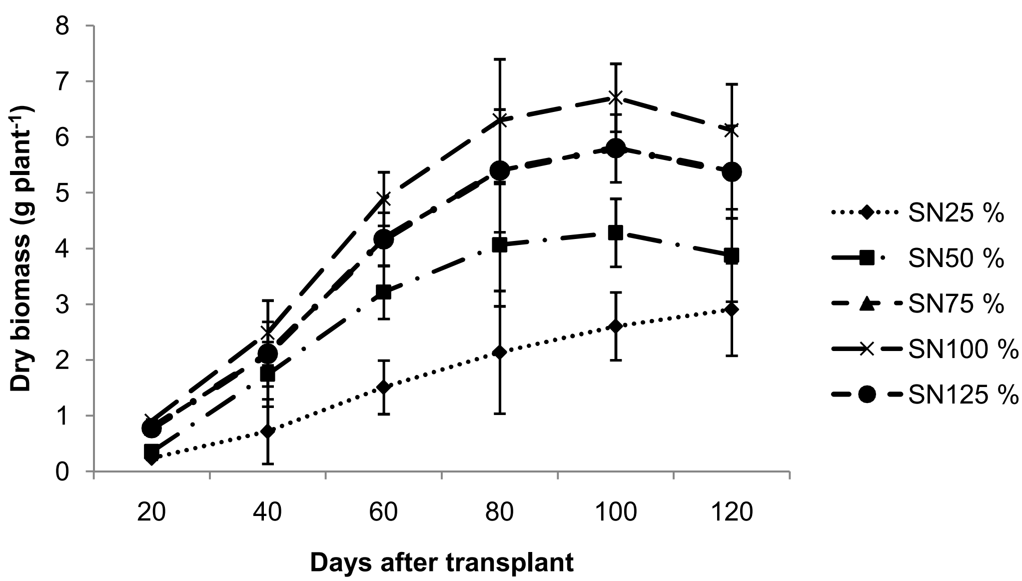


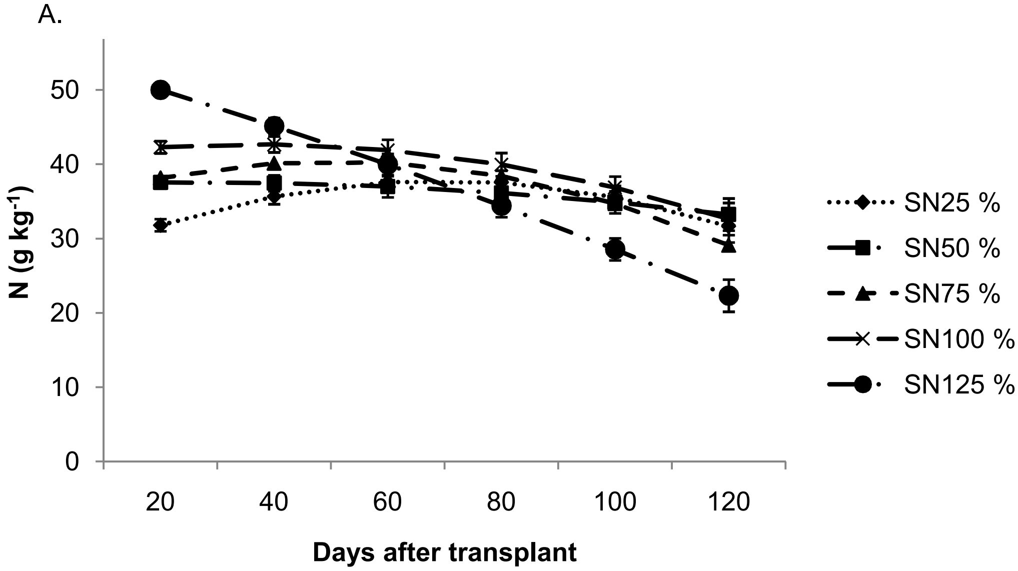
Fig. 3. Total dry matter yield (g plant^{-1}) in commercial-size (≥ 15 cm) *M. spicata* L., at five concentration levels of universal nutrient solution [11]

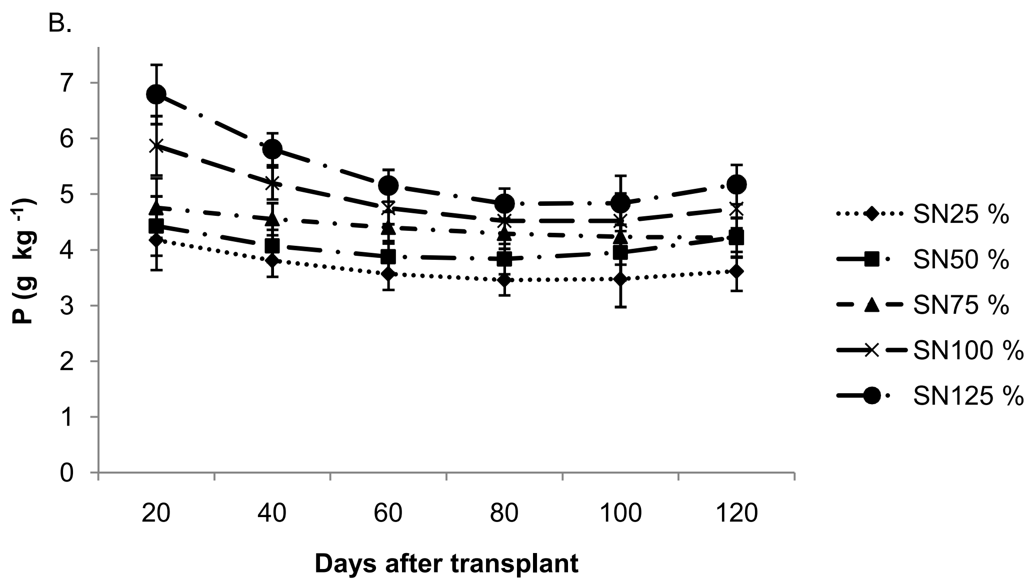
There were some differences in the amount of N removed in the different sampling periods (Fig. 4A), but they are in the range reported by [9] who obtained an average of 33.8 g kg^{-1} of N in mint plant tissue. In other hand, they indicate that N levels below 2 g kg^{-1} were deficient in other species, but in the mint crop it is not related to a critical level. Changes in nitrogen accumulation between treatments may be due to the response of the plant to the extraction of N that depends on the supply thereof in the nutrient solution [16]. In this regard, [17] indicate that nitrogen fertilization increases fresh biomass yield when the N dose is doubled.

Fig. 4B shows phosphorus removal by the mint crop. During the first harvest, there were significant differences among treatments. Beginning with the second harvest, phosphorus removal was above 5 g kg^{-1} in the 75, 100 and 125% NS treatments, because these have a higher concentration of this nutrient in their chemical composition. In the third and fourth harvest there were no significant differences. The results in all treatments coincide with the range reported by [5], who established as a range 2.4-6.4 g kg^{-1} of P absorbed. It is not until the fifth harvest that there was a significant increase for the 75, 100 and 125% NS treatments, which obtained 4.15, 4.7 and 4.05 g kg^{-1} of P respectively. There were no significant differences in the last harvest. In this way, an adequate supply to P is important through the growing season and stimulates new root growth after harvest [6].

The behavior of potassium removal is shown in Fig. 4C, where it can be seen that in the initial stages of cultivation there were no significant differences among treatments (P = 0.05). In the fourth and fifth harvest there were significant differences between the 50 and 125% NS treatments, which obtained 40.2 and 27 g kg^{-1}, respectively. It was not until the fifth harvest that K was extracted in a greater amount and it was for the 100% NS treatment (40.20 gkg^{-1} dry matter). These results are in the range of 10.07 to 43.5 g kg^{-1} determined by [5], who also indicate that K is the element that is found in the greatest concentration in mint plant tissue followed by N and P. In this study, the highest concentration was N, followed by K and P, due to the accumulation of nutrients which has a direct relationship with the ionic concentration present in the nutrient solution [7].

A.





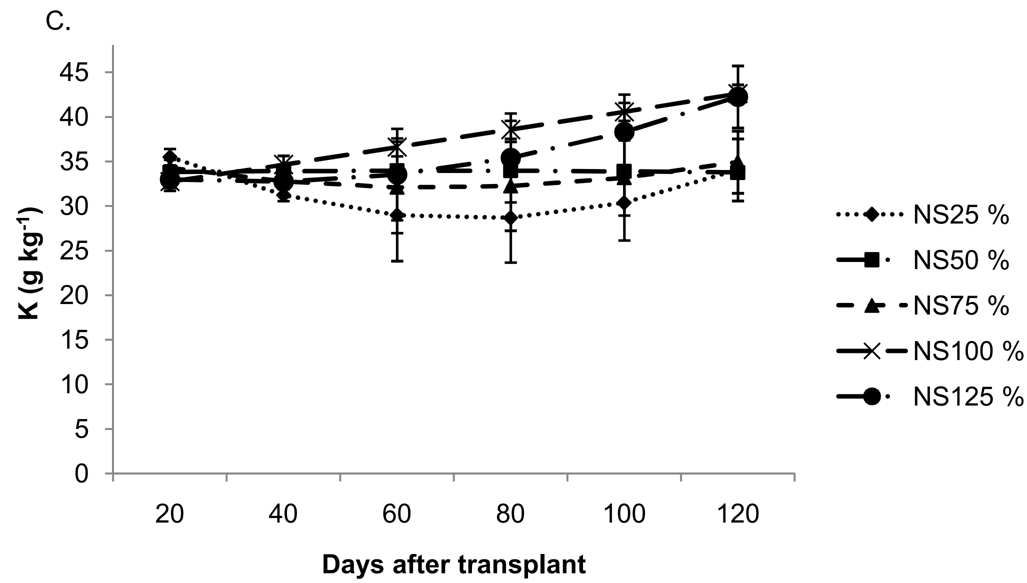


Fig. 4A. Nitrogen removal (g Kg^{-1}), B. Phosphorous removal (g Kg^{-1}) and C. Potassium removal (g kg^{-1}) in *Mentha spicata* L. grown in substrate and at five concentration levels of universal nutrient solution.

4. CONCLUSION

The concentration of the nutrient solution modified fresh and dry biomass production in mint plants, with the 100 % concentration being the ideal level to produce more economic yield from 60 DAT. It had a 34% increase in these parameters with respect to the lowest concentration (25%), which is due to an increased supply and availability thereof in the plant roots. In connection with the harvest season from 60 DAT, the concentration of the nutrient solution must be increased for optimal yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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