

# Inadequate Nitrogen Fertilization: Main Cause of the Low Seed Yield on the Chia Crop (*Salvia hispanica* L.)

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## Introduction

Chia (*Salvia hispanica* L.) is a Mexican ancestral crop that for its nutritional properties presents high demand in the international market, its growth rate is 239% annually and it is estimated that by 2020 its sales will be \$ 1.2 billion dollars [1]. Since 1917, it has been reported that the maximum attainable seed yield (SY) on chia is close to 3.0 t ha<sup>-1</sup> [2-5]; however, the SY that the farmers commonly achieve in commercial plots is lower, and on average it only is 0.36 t ha<sup>-1</sup> [6]. According to [7], the low productivity on chia due to their agronomic management has not been modernized, and to this date it still is cultivated mainly on rainy season, and the use of fertilizers, pesticides and improved varieties is scarce. The plasticity of the chia to adapt and produce under a low-input systems has led erroneously to assume that it presents low requirements of water and fertilizer [8,9], and also it resists the attack of pests and diseases [10].

Therefore, although its integration into the modern agriculture started since 1991, to this date is unknown how the production controllable factors (improved varieties, planting date irrigation, plant density, and other ones), and particularly the fertilization with macro and micronutrients affects their productivity. Regarding with the nitrogen fertilization, the consulted literature indicates that the higher nitrogen rate evaluated on chia is 45 kg ha<sup>-1</sup> [11]. If it is assumed that this specie take up 80% of this rate, and it produces 16.7 kg of seed per each kg of N absorbed, the maximum attainable SY could be 601 kg ha<sup>-1</sup>. Considering that this value is consistent with the SY achieved at 1935 [12] when the nitrogen use was scarce [13], we developed the hypothesis that the inadequate nutrition could be the main cause because the SY on chia has not improved in the last 83 years. To confirm this assumption, during 2016-2017 we conducted two trials to evaluate the response of four chia varieties to different nitrogen rates.

The findings of both these studies showed that under of edaphoclimatic conditions of Toliman Jalisco, México, the productive potential of chia (2.21 t ha<sup>-1</sup>) is six times higher than

the world average (0.36 t ha<sup>-1</sup>), and also, that it can be increased by using improved varieties combined with an adequate nitrogen fertilization [7]. The application of 100 kg N ha<sup>-1</sup> along with the use of the experimental genotype G-39 (during 2018, Nutriline Co. will patent this genotype with the name of "Rehnborg") allowed to obtain a SY of 2.21 t ha<sup>-1</sup>, and even, when the G-39 cultivar is established in an optimal sowing date, the SY is close to 3.0 t ha<sup>-1</sup> [14]. These results differ that those reported in other parts of the world, because the most of them found no response of the chia crop to nitrogen application [15,16]. The study published by [7] is the first one where the response of the chia crop to nitrogen fertilization is based on the SY, and the results obtained clearly suggest that in order to improve the potential productive on chia, besides developing yielder cultivars, there should also be generated fertilization norms that ensure the adequate nutrition of this oilseed. Historically the nitrogen fertilization is the agronomic practice that has most helped to increase the crop yields [13,17-20] and, according to our results we estimated that the nitrogen fertilization could help to raise on 63% the SY on chia.

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