Renewable and Sustainable Energy Reviews 81 (2018) 464–472

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

# Crambe grain yield and oil content affected by spatial variability in soil physical properties

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ARTICLE INFO

*Keywords:*
Energy crops
Structural state
Spatial correlations

ABSTRACT

Crambe (*Crambe abyssinica* Hochst) is a Brassicaceae crop with high potential for biofuel production without conflict with food industry and with similar energy performance to fossil fuels, but there is almost no information on soil conditions affecting crop grain and oil production. We studied the spatial correlation between soil porous space, soil resistance to penetration, and bulk density of a clayey Oxisol (Ferralsol) with crambe grain yield and oil content. Four states of compaction were generated by using a roller compactor, in a 1-ha field, and 133 georeferenced sampling points were selected. In two consecutive years, these positions were used for soil physical characterization, and crambe harvesting for grain yield and oil content determinations. Soil resistance to penetration, bulk density, and pore space properties showed spatial dependence structure over time in three soil layers. After two years of crambe cultivation, soil bulk density and soil resistance to penetration values increased, and soil porosity decreased in all soil layers, showing that crambe root system was not able to improve soil physical composition properties. Soil bulk density up to 1.3 Mg $m^{-3}$ reduced grain yield and increased oil content of crambe. Increased soil bulk density and resistance to penetration, caused by additional soil compaction, changes crambe source/sink relationship, resulting in lower crambe grain yield, but in grains with higher oil content.

## 1. Introduction

There has been a growing incentive for research on renewable fuel sources, especially after the International Treaty on Global Warming, which requires the replacement of fossil fuel by alternative energy-sources [1]. This motivation is based on the environmental impacts caused by the use of fossil fuels, growing global concern about oil inventories [2], and carbon dioxide release to atmosphere increasing the average temperature of soil and oceans [3].

The core of sustainable energy development is energy security [4], and biomass can significantly enhance energy-supply security, revitalize agriculture economy, and boost the technology of energy industry [5]. Biofuels are an environmentally sound alternative to reducing the use of fossil fuels [6] and show similar performance to fossil fuels and engines do not require adjustments [7].

Although the Brazilian National Program for Production and Use of Biodiesel mandated the inclusion of 5% biofuel in all fuel oil sold domestically after 2013, there are several constraints in biodiesel production, such as small supply of raw materials, shortage of vegetable oil, and high prices of available raw materials [8].

Among potential energy-crops, crambe (*Crambe abyssinica* Hochst) stands out due high oil content and crop cycle not competing with food production [9]. Although crambe is a crop with high potential for biofuel productions, there is little information on soil physical conditions to increase crop grain yield and oil content. Nonetheless, there are some evidences that crambe oil content is not associated with grain yield [10], which needs further confirmation in field trials. For other agricultural crops, the effect of soil compaction on crop yield is studied more extensively [11–13], but also its effect is not always clear under for no-tillage cropping [12].

A genus of the cabbage family Brassicaceae, crambe has dense racemes of tiny white or yellow flowers on stems above the basal leaves (Fig. 1). Crambe is a winter crop with low production cost, easily adaptable to crop rotation, tolerant to drought and frost, adapted to low soil fertility, and holds an aggressive root system [9]. Aggressive rooting systems act as biological [14,15] or root chisels [16] to establish

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http://dx.doi.org/10.1016/j.rser.2017.08.003
Received 17 June 2016; Received in revised form 24 May 2017; Accepted 2 August 2017

**Fig. 1.** – Crambe single plants (a), field view (b), seeds near physiological maturity (c) and harvested seeds (d). Photos by Araceli Marins.

a network of conductive pores and ameliorate soil compaction [14], but the effect of soil compaction on crambe and its effect on the soil are largely unknown.

Spatial distribution of soil physical properties contributes in defining management practices and designing irrigation and drainage systems. Soil management practices may affect positively or adversely soil quality and, consequently, grain yield and quality [17]. Variations in soil and crop properties are important for site-specific management for maximizing crop yield potential [18].

The hypothesis of this study was that heavy traffic affecting soil bulk density, pore space and soil resistance to penetration reduce grain yield and oil content of crambe. Our objective was to assess the spatial relation between compaction states and crambe grain yield and oil content, and to evaluate the effect on soil structure of crambe growth.

## 2. Materials and methods

### 2.1. Experimental area, climate, and soil

The experiment took place in Cascavel, southern Brazil, in an area of 1 hectare, located at coordinates 24°56′17″S latitude and 53°30′56″W longitude, at an average altitude of 760 m. Local climate is temperate/mesothermal and super-humid (Cfa), according to the Köppen classification, with annual precipitation of 1620 mm, well distributed rainfall during summer season, and air temperature around 21 °C. The soil is classified as an Oxisol (Ferralsol) or "Latossolo Vermelho Distroférrico típico" in the Brazilian Soil Classification System [19], a red highly-weathered soil, with high clay content and deep profile, developed from basaltic rock, and positioned on undulated relief.

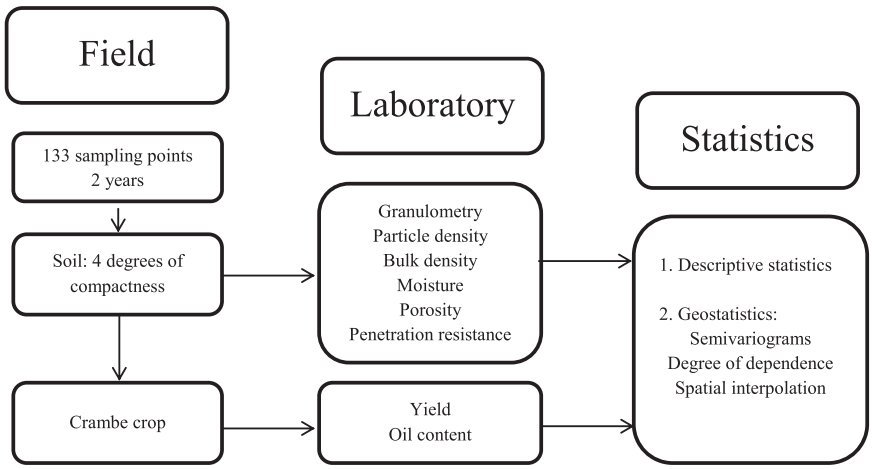


**Fig. 2.** – Methodology flow chart showing field, laboratory and statistics details.