Impact of soil compaction on the engineering properties of potato tubers

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Abstract: A study on a 30 hm^2 field was conducted to assess the variability in soil compaction and to investigate its effect on the engineering properties of potato tubers in terms of tuber shape and key dimensions (length, width and thickness) and resistance to penetration, rupture and shear forces. Three soil compaction levels were spatially correlated with the engineering properties of potato tubers through linear regression and ANOVA test. The three compaction levels included a low level (C1) ranging between 1.2-1.9 MPa, a medium level (C2) with compaction levels between 2.0-2.3 MPa and a high level (C3) ranging between 2.4-2.9 MPa. Results revealed that there were no significant changes in the key tuber dimensions corresponding to the variability in soil compaction. However, inverse linear relationships were observed between soil compaction and the key tuber dimensions with R^2 values of 77%, 97% and 96% for length, width and thickness, respectively. Similarly, the soil compaction was shown to have no effect on the tuber resistance to compression and shear force. In contrast, the tuber resistance to penetration was significantly affected by soil compaction ($p>F=0.0012$).

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1 Introduction

Soil compaction is generally defined as the increase in soil density mostly due to the pressure on the soil[1]. The existence of compacted layers of dense soil near the soil surface is often attributed to the use of heavy machinery or the cultivation of wet soils. Deep compacted layers; however, may be caused by heavy harvesting machinery or trailers at times when the soil is too wet to withstand these high axle loads. The need to plant crops over a limited time window may increase the risk of soil compaction when working in soil of an inappropriate condition. A certain degree of soil compaction is needed for crop growth, so that a good seed-soil contact can help stabilize the roots and improve water absorption. In contrast, a very low soil compaction around potato tubers at the planting time could delay crop emergence. The shallow rooting system of potatoes (about half of the effective rooting depth of cereals) makes them more sensitive to unfavorable soil conditions, such as low soil moisture and high soil compaction, compared to other crops[2].

Under natural conditions, field soil physical properties were found to be of high horizontal and vertical spatial variability that can persist over time[3]. Therefore, there is an urgent need to study the spatiotemporal changes in soil properties, which introduces the need to use tools, such as geostatistics[4]. These tools allow study on the spatial and temporal distribution of soil properties, such as moisture and compaction[5], which are critical factors in vegetation cover and land-use changes[6]. Changes in these soil attributes can principally affect some important properties, such as particle size, soil structure and hydraulic conductivity[5]. Understanding the spatial variability of soil physicochemical characteristics in their dynamic forms (for example, compaction and water content) is necessary for site-specific management of agricultural practices, as they directly contribute to the variability in crop yield and quality[7].

Soil compaction is an important factor deemed in soil degradation. This is manifested by a reduction in the volume of soil and an increase in its bulk density, which reduces soil porosity and influences the shape and size distribution of the soil pores[8]. In industrial and developing countries, potatoes are particularly important in the food chain among agricultural products. Potatoes contain an amount of energy equivalent to 830 calories per kilogram[9]. There are some situations in which the determination of relationships among physical characteristics of agricultural products is necessary; for example, some fruits are graded by size[9]. Similarly, physical characteristics of agricultural products are the most important parameters for the design of grading, handling, processing and packaging systems, these physical characteristics include the mass, shape and volume, and the width, length and thickness[10,11].

Understanding the mechanical characteristics of potato tubers may improve harvesting and handling equipment and reduce economic losses. In addition to size and shape, the texture of tubers is also an important factor in the technical classification of

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