Rainfall intensity effects on crusting and mode of seedling emergence in some quartz-dominated South African soils

Adornis D Nciizah[1] and Isaiah IC Wakindiki[1]*

[1] *Department of Agronomy, University of Fort Hare, Private Bag X1314, King William's Town Road, Alice 5700, South Africa*

ABSTRACT

Predicted changes in rainfall intensity due to climate change are likely to influence key soil health parameters, especially structural attributes and crop growth. Variations in rainfall intensity will impact crop production negatively. It is therefore imperative to investigate the interaction between predicted increases in rainfall intensity and key soil health parameters, particularly in relation to soil structural attributes and plant growth. The objectives of this study were to determine the effects of rainfall intensity on soil crust formation and mode of seedling emergence in soils dominated by primary minerals. Soil samples were collected from the top 200 mm, air dried and then packed uniformly into plastic pots, which were perforated at the bottom. Three maize seeds of equal size were planted in a triangular pattern in each pot at a depth of 30 mm, after which the pots were pre-wetted by capillary. The samples were then subjected to simulated rainfall at 3 intensities, i.e., 30, 45 and 60 mm/h, for 5 min. Rainfall intensity significantly ($P < 0.05$) affected crust strength and mean emergence day (MED), but not emergence percentage (EMP) and shoot length ($P > 0.05$). The 60 mm/h rainfall intensity resulted in the highest crust strength and MED. The strength of crust for all three rainfall intensities was influenced by quartz content, soil organic matter, clay and hematite. Most seedlings emerged through cracks, which resulted in rainfall intensity having no significant effects on seedling EMP and shoot length. We concluded that any increase in rainfall intensity is likely to increase the severity of crusting in these soils. However, soils with extensive cracking are likely to have higher EMP and lower MED and more vigorous seedlings despite the strength of the crust. As a result, post-planting tillage methods that enhance crust cracking may be employed to enhance seedling emergence and growth in these soils.

Keywords: climate change, crusting, mineralogy, penetration resistance, soil organic matter

INTRODUCTION

Changes in climate are projected to cause variations in rainfall characteristics (IPCC, 2007; Davis, 2010; Allen et al., 2011). Global climate models have shown that global warming will increase the intensity of extreme precipitation events, even in areas where mean rainfall decreases with longer periods between rainfall events (IPCC, 2007). Moreover, similar regional models have indicated significant changes in rainfall intensity in South Africa (UNICEF, 2011). An up to 50% increase in the intensity of 10-year high-rainfall events along the east coast of South Africa was predicted by Mason et al. (1999) and Shongwe et al. (2009). In general, such variations in rainfall patterns and intensity, coupled with rising temperature, affect crop yield directly and indirectly through changes in irrigation water availability (Soriano-Soto et al., 1995; Nelson et al., 2009). Whilst it is generally agreed that changes in climate will have dire effects on agriculture, the exact nature of these biophysical effects and the human responses to them are complex and uncertain, thus adding considerable uncertainty to assessment efforts (Adams et al, 1998; Walthall et al., 2012). For instance, crop simulation models usually used to determine the effects of climate change on crop productivity have limitations, which include isolation from the variety and variability of factors and conditions that affect production in the field (Adams et al., 1998; Nelson et al., 2013). In a USDA report (Walthall et al., 2012), it was noted that a healthy soil should have appropriate levels of nutrients necessary for the production of healthy plants, moderately high levels of organic matter, a soil structure with good aggregation of the primary soil particles and macro-porosity, moderate pH levels, thickness sufficient to store adequate water for plants, a healthy microbial community, and absence of elements or compounds in concentrations toxic for plant, animal, and microbial life. However, changes in climate, particularly rainfall intensity, will result in sealing, crusting, erosion and loss of organic matter, which influences soil health although the effects are complex. Therefore, it is imperative to investigate the interaction between the predicted increases in rainfall intensity, key soil health parameters, especially structural attributes, and plant growth. Such an understanding will assist in adapting to change and hence reduce vulnerability to climate change.

Soil structure determines aggregate stability and organic matter turnover, which, in turn, affect crust formation (Wakindiki and Ben-Hur, 2002; Augeard et al., 2008; Fan et al., 2008; Allen et al., 2011). Apart from the soil properties, rainfall characteristics, especially intensity, affect crust formation (Assouline, 2004; Liu et al., 2011). Accordingly, at high intensity, rainfall exceeds the infiltration capacity of the soil more quickly, leading to ponding (Hillel, 1998). In that saturated condition, the soil structure is less stable and the soil aggregates break down faster under raindrop impact and rapid wetting (Liu et al., 2011). Moreover, higher rainfall intensity produces larger size raindrops with higher impact energy that enhances crust formation (Moussouni et al., 2013). However, in South Africa, work simulating the effects of changing rainfall intensity due to climate change on soil structure attributes such as crust formation is scant.

* To whom all correspondence should be addressed.

☎ +27 40 6022096; e-mail: iwakindiki@ufh.ac.za

Received 9 September 2013; accepted in revised form 3 September 2014.

http://dx.doi.org/10.4314/wsa.v40i4.2
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 4 October 2014
ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 4 October 2014