Rainfall pattern effects on crusting, infiltration and erodibility in some South African soils with various texture and mineralogy

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ABSTRACT

Rainfall characteristics affect crust formation, infiltration rate and erosion depending on intrinsic soil properties such as texture and mineralogy. The current study investigated the effects of rainfall pattern on crust strength, steady state infiltration rate (SSIR) and erosion in soils with various texture and minerals. Soil samples from the top 0.2 m layer were exposed to 60 mm·h^{-1} simulated rainfall. The rainfall was applied either as an 8-min single rainstorm (SR) or 4 x 2-min intermittent rainstorms (IR) separated by a 48 h drying period. Rainfall pattern significantly ($p < 0.05$) affected crust strength, SSIR and erosion. The IR resulted in higher crust strength and SSIR than SR. The effect of rainfall pattern on SSIR was mostly influenced by the primary minerals, namely, quartz. Therefore, the predicted shift from long duration to short duration rainstorms due to climate change is likely to enhance crust formation and soil loss in semi-arid areas such as the Eastern Cape Province of South Africa.

Keywords: hydrology, penetration resistance, quartz, soil organic matter

INTRODUCTION

Raindrops break down soil aggregates and set off the process of physical crust formation (Assouline, 2004; Carmi and Berliner, 2008; Bu et al., 2013). The ensuing breakdown and consolidation of micro-aggregates and soil particles alter soil surface hydraulic processes such as steady state infiltration rate (SSIR) and runoff (Carmi and Berliner, 2008). Consequently, both soil and rainfall characteristics that determine the nature of crust formation have been extensively investigated in many environments (Stern et al., 1991; Wakindiki and Ben-Hur, 2002; Carmi and Berliner, 2008; Wuddivira et al., 2009; Bu et al., 2013). This widespread and sustained interest in the soil crusting phenomenon signifies both its importance and the lack of a full understanding of its impact on the environment. Among the most investigated soil properties in this regard are texture (Stern et al. 1991; Kay and Angers, 1999; Lado et al., 2004; Wuddivira et al., 2009), soil organic matter (Lado et al., 2004) and mineralogy (Wakindiki and Ben-Hur, 2002; Khun and Bryan 2004; Mamedov et al., 2006; Lado et al., 2007). Wakindiki and Ben-Hur (2002) showed that kaolinitic soils are significantly less susceptible to crust formation than smectitic ones. Similarly, Lado et al. (2007) showed that 2:1 clays are more dispersive than 1:1 clays. Crust formation decreases with increase in clay content because clay particles bind aggregates together contributing to cohesive strength of the aggregates (Boix-Fayos et al., 2001; Chenu et al., 2000; Levy and Mamedov, 2002). Despite acknowledgement that soil mineralogy influences crust formation, only a few studies have dealt with soils dominated by primary minerals. Most likely the low adsorption capacity of quartz (Buhman et al., 2006) makes it less important with regard to plant nutrition. However, the low specific surface area of quartz promotes rapid soil organic matter (SOM) mineralisation resulting in poor aggregate stability (Buhman et al., 2006). Soils in most parts of the Eastern Cape Province are dominated by primary minerals such as quartz (Mandiringana et al., 2005; Nciizah and Wakindiki, 2012), and are highly susceptible to crust formation (Stern et al., 1991; Mills and Fey, 2004).

On the other hand, effects of rainfall characteristics such as depth (Fan et al., 2008), intensity (Truman et al., 2007) and duration (Augeard et al., 2008) on crust formation are well-known. However, new thinking is being prompted by the current forecasts of climate change's potential effects on soil health and water resources. For example, it is predicted that climate change will alter both rainfall patterns and intensity (Davis 2010; Allen et al., 2011). Rainfall patterns will become more sporadic and the frequency of drought periods will increase in semi-arid regions such as the Eastern Cape Province (Davis, 2010; Financial & Fiscal Commission, 2012). Nevertheless, the exact effects of these climatic changes on surface sealing, crusting and soil erosion are not entirely understood. Kuhn and Bryan (2004) highlighted the existence of soil–climate interactions and stressed the need for the development of a general concept for climate–soil structure interaction. Their study highlighted differences in sensitivity of the soils used to changes in soil condition on drying and subsequent interrill erosion. A 2-fold increase in erosion during dry conditions was observed in clay-textured soils, reinforcing the assertion that crust formation is influenced by rainfall pattern and soil properties. Therefore, there is a need to study the corresponding response of the soil surface to such changes. In so doing, the promotion of environmentally sustainable production systems leading to minimised degradation, as enshrined in the South African Department of Agriculture, Forestry and Fisheries Strategic Plan (DAFF, 2010), may be achieved.

Although the dire impact of climate change on soil structural behaviour is acknowledged (Allen et al., 2011; Kuhn and Bryan, 2004), less effort has been made to offer quantitative investigations in South Africa with regards to the influence of climate change on crust formation. Instead, much research has

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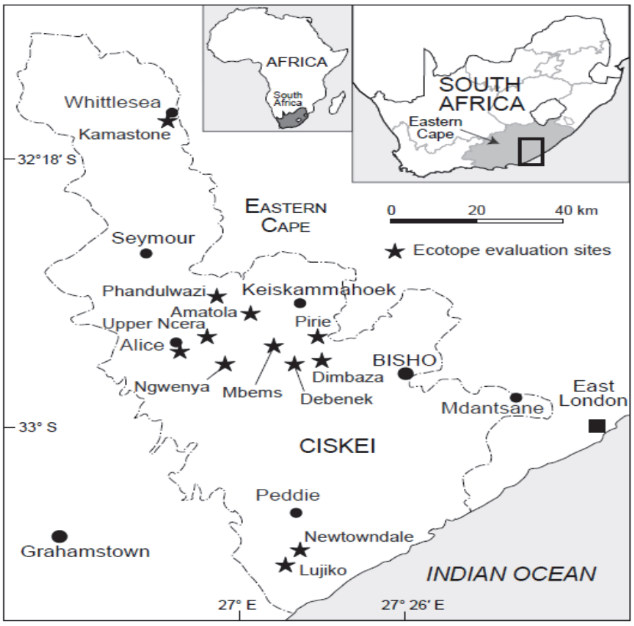

Figure 1
Soil sampling sites (Nciizah and Wakindiki, 2012)

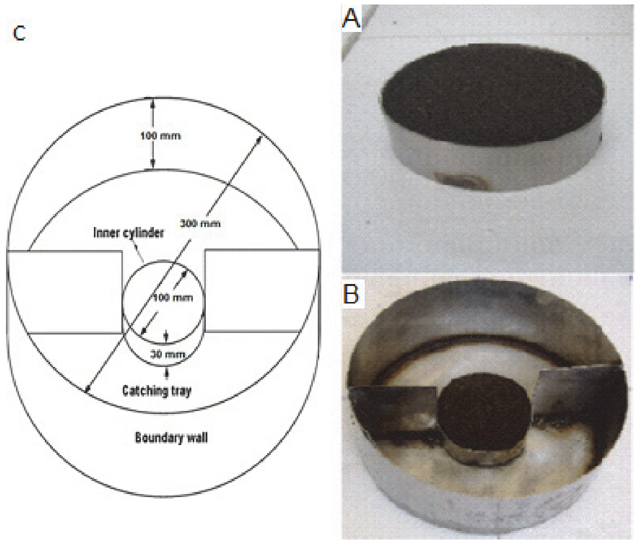

Figure 2
Splash plate with splash cup inside

focused on catchment hydrology (Van Tol et al., 2010), in-field water harvesting (Hensley et al., 2011) and runoff measurement on crusted soils (Hensley et al., 2000; Zere et al., 2005). The latter studies bring to light the positive aspects but ignore the massive negative contribution of soil crusting in agricultural landscapes.

Consequently, the objective of this study was to determine the effects of rainfall pattern on crust strength, SSIR and erosion in soils with various texture and mineralogy in South Africa. It was hypothesised that rainfall pattern affects crust strength, SSIR and erosion in soils, depending on their texture and dominant mineralogy.

MATERIALS AND METHODS

Soil sampling

Soil samples with varying properties were collected from the surface (0) to 0.2 m from 13 ecotopes in Eastern Cape Province (Fig. 1). The soil samples were air-dried for a week. The < 2 mm fraction was characterised for initial properties. The following determinations were done: pH and EC in water following methods described by Okalebo et al. (2000), particle size distribution according to Gee and Or (2002), SOM content as described by Cambardella et al. (2001) and soil mineralogy according to the Rietveld method as described by Zabala et al. (2007). More information about soil sampling and initial characterisation is given by Nciizah and Wakindiki (2012).

Crust formation

The soil samples were packed into splash cups (Fig. 2A) in 3 replicates and pre-wetted by capillary rise. The splash cups were then placed in a splash plate (Fig. 2B). The plate was made from a thin sheet of iron with an outside diameter of 0.3 m and a height of 0.1 m (Fig. 2C). The splash cup had a cross-sectional area of 0.07 m^2 and a depth of 0.3 m. The perforations at the bottom of the splash cups were covered with a piece of gauze and a filter paper to prevent soil loss and permit drainage (Nciizah and Wakindiki, 2012). The splash cups were then placed in a splash plate and exposed to simulated rainfall.

Rainfall simulation

Rainfall was applied either as 8-min single rainstorm (SR) or 4 x 2-min intermittent rainstorms (IR) separated by a 48 h drying period. These rainfall patterns and drying period treatments were adopted to mimic the predicted climate scenarios (Davis, 2010; Allen et al., 2011). The specific drying period was adapted from Knapen et al. (2008). A rainfall simulator for erosion tests (LUW, Eijkelkamp Equipment, 6987 ZG Giesbeck, Netherlands) was used. The simulator had 49 capillary tubes and applied raindrops of 5.9 mm in diameter. The splash cups containing the soil samples were slowly pre-wetted from the bottom with tap water until saturated, and then placed under the rainfall simulator. The soil samples were then subjected to simulated rainfall at 360 $mm \cdot h^{-1}$. The high intensity rainfall was used to compensate for the short falling distance, of 0.4 m, of each simulated raindrop and the resulting low volume-specific kinetic energy of the applied shower, as suggested by Martin et al. (2010). The time-specific energy of the simulated rain was 1 440 $J \cdot m^{-2} \cdot h^{-1}$. Natural rainfall events with this time-specific kinetic energy approximate natural rainfall intensities of approximately 60 $mm \cdot h^{-1}$ (Martin et al. 2010). A total of 210 rainfall simulations were done. Soil crust properties were determined after air drying the soils for 1 week.

Splash erosion, crust strength and steady-state infiltration rate

After each rainstorm the splash cup was removed from the splash plate, taken for air-drying and replaced with another one. Splashed sediment was washed out of the splash cup into a jar, dried at 105°C for 24 h and weighed thereafter. Crust measurements were done after air-drying the soil sample for 1 week. A similar drying period was used by Wakindiki and Ben-Hur (2002). Crust strength was estimated in each splash cup from

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3 positions by slowly and steadily pushing a flat-point miniature hand-held penetrometer (Geotest Instrument Corp) into the top 0.05 m of the soil. The SSIR was determined using a mini disk infiltrometer (Decagon Devices, 2007). This instrument allows water to infiltrate while under tension to prevent the filling of the macropores. Therefore, the resultant hydraulic conductivity is characteristic of the soil matrix, and is less spatially variable (Dohnal et al., 2010; Decagon Devices, 2007). For most soils, water flow in macropores is eliminated when the suction is kept at 0.02 m. However, sandy and clay soils require higher and lower suction, respectively (Decagon Devices, 2007). The soils used in this study were sandy loam, sandy clay loam or loam, therefore a suction rate of 0.02 m was adopted. Crust samples were carefully removed from the splash cups by hand and placed on a thin layer of the same soil in petri-dishes. A thin layer (~3 mm) of silica sand was applied to the crust surface to smoothen it and give good contact between the soil crust surface and the infiltrometer. The infiltration test was started by recording the initial volume of the water in the reservoir. Thereafter, readings of the remaining volume of water in the reservoir were taken at 30 s intervals until 20 mℓ had infiltrated, as recommended by the manufacturer (Decagon Devices, 2007). Cumulative infiltration *I* was estimated as proposed by Zhang et al. (1997) in Eq. (1).

$$I = C_1 t + C_2 \sqrt{t} \quad (1)$$

where:

C_1 (m·s^{-1}) was a parameter related to the hydraulic conductivity *k*
C_2 (m·s$^{-½}$) was the soil sorptivity
t was the time interval (*s*)

Equation (2) was used to compute *k*.

$$k = \frac{C_1}{A} \quad (2)$$

where:

C_1 was the slope of the curve of *I* and $\sqrt{t}$ that was obtained using the basic Microsoft Excel® spreadsheet developed by Decagon Devices (2007).

Value *A* related the Van Genuchten parameters for each soil texture class to the suction and radius of the infiltrometer disc. The Van Genuchten parameters were obtained from Carsel and Parrish (1988). The value of *A* was then computed using Eq. (3) (Dohnal et al., 2010).

$$A = \frac{11.65\left(n^{0.1} - 1\right)\exp\left[7.5\left(n - 1.9\alpha h_0\right)\right]}{\left(\alpha r_0\right)^{0.91}} \quad 1.35 \le n \le 1.9 \quad (3)$$

where:

n and α were the Van Genuchten parameters. For sandy loam soils, *n* was 1.89 and α was 1.89. For sandy clay loam soils, n was 1.48 and α was 0.059. The disc radius, r_0, was 22.5 mm, and the suction at the disc surface, h_0 was 20 mm.

Data analysis

Analysis of variance (ANOVA) was performed using JMP 10 (SAS Institute, 2012). Mean separations were done using Fisher's protected least significant differences (LSD) at P< 0.05.

RESULTS

Chemical, physical and mineralogical properties of study soils

Some chemical, physical and mineralogical properties of the soils used in this study are shown in Table 1. The soil mineralogy was dominated by primary minerals, mainly quartz. The most dominant textural classes were sandy clay loam and sandy loam (Table 1). Climatic conditions were mostly semi-arid whilst a few were sub-humid. Exchangeable bases, exchangeable sodium percentage (ESP) and sodium absorption ratio (SAR) of the soils is shown in Table 2. The SAR for all the soils was below 15 cmol(+)·kg^{-1} whilst the ESP was below 6% for all the soils. Consequently the soils were non-sodic.

Rainfall pattern effect on soil penetration resistance in soils with different texture and mineralogy

Rainfall pattern had a significant (p< 0.05) effect on the crust's penetration resistance depending on the soil's texture and

TABLE 1
Selected soil physical, chemical and mineralogical properties for the 13 soils

Ecotope	Management	Texture %			EC µSm^{-1}	Textural class	Climate	pH	SOM g·kg^{-1}	Soil mineralogy, %						
		Sand	Clay	Silt						H#	K	Mi	Mu	P	Q	S
Alice Jozini	Cultivation	60	12	28	47.9	SL*	SA*	5.78	35.7	0.29	-	4.4	6.1	12.2	77.01	-
Amatola Jozini	Cultivation	47	37	15	28.47	SCL	SH	5.80	66.1	1.91	32.4	4.36	2.74	9.29	28.88	14.7
Debenek	Cultivation	56	18	26	49.23	SL	SA	5.79	24.0	0.3	2.1	4.59	8.5	84.5	-	-
Kamastone	Cultivation	72	19	9	66.47	SL	SA	6.27	31.8	0.67	8.56	10.0	18.8	5.9	5.96	-
Lujiko Leeufontein	Cultivation	68	19	11	52.23	SL	SA	5.45	38.2	0.63	-	8.61	5.14	10.4	75.14	-
Mamatha	Cultivation	61	18	21	34.50	SL	SA	5.50	29.9	0.43	-	5.52	6.46	12.2	75.32	-
Mbems Koedosvlei	Pasture	56	21	23	55.17	SCL	SA	5.65	34.3	1.1	-	4.99	6.58	9.97	77.35	-
Mbems Koedosvlei	Cultivation	56	22	22	80.97	SCL	SA	5.76	42.7	0.65	-	4.69	7.76	10.5	76.37	-
Ncera Kinross	Cultivation	48	26	26	61.50	SCL	SH	5.08	41.9	1.12	9.3	4.48	3.12	8.23	61.9	9.9
Newtondale	Cultivation	65	21	14	40.34	SCL	SA	6.25	51.4	0.76	-	10.5	7.83	8.11	72.74	-
Ngwenya Jozini	Cultivation	72	18	10	41.27	SL	SA	6.49	36.4	0.56	-	8.83	5.78	16.6	68.22	-
Ngwenya Swartland	Pasture	67	21	12	53.57	SCL	SA	5.53	28.4	0.66	-	7.5	6.51	17.2	68.11	-
Phandulwazi Jozini	Pasture	58	21	21	37.80	SCL	SA	5.49	24.7	0.58	-	0.98	3.95	7.64	86.85	-

H# = hematite, K = kaolinite, Mi = microline, Mu = muscovite, P = plagioclase, Q = quartz, S = smectite
SC = sandy clay, SL = sandy loam, SCL = sandy clay loam, L = loam*
SA = semi-arid, SH = sub-humid (Nciizah and Wakindiki, 2012)*

TABLE 2
Exchangeable bases, sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) for the 13 soils

	Exchangeable bases cmol(+)·kg^{-1}			SAR	ESP %
Ecotope/soil	Na	Mg	Ca		
Alice Jozini	1.12	2.07	77.31	0.12	2.08
Amatola Jozini	0.16	2.80	87.65	0.01	1.96
Debenek	0.27	1.87	35.58	0.04	2.00
Kamastone	0.18	2.36	64.69	0.02	1.97
Lujiko Leeufontein	0.31	1.54	32.15	0.06	2.00
Mamatha	0.81	2.12	69.74	0.09	2.04
Mbems Koedosvlei	0.28	2.64	123.72	0.02	1.98
Mbems Koedosvlei f	0.30	1.48	31.41	0.06	2.00
Ncera Kinross	0.52	1.20	27.40	0.11	2.06
Newtondale	0.38	2.22	61.92	0.05	2.00
Ngwenya Jozini	0.18	1.25	48.47	0.03	1.97
Ngwenya Swartland	0.23	1.63	48.25	0.03	1.98
Phandulwazi Jozini	0.45	1.11	26.17	0.09	2.04

mineralogy (Table 3, Fig. 3a–d). The PR values for the SL and SCL were 1.84 kg·m^{-2} and 1.16 kg·m^{-2}, respectively. For quartz-dominated soils, the PR value was 1.90 kg·m^{-2} whilst a PR value of 1.10 kg·m^{-2} was observed for the kaolinitic soils (Fig. 3b). Crusts with a PR value of 1.14 kg·m^{-2} were formed after SR compared to 1.86 kg·m^{-2} after the IR pattern. However, there was significant interaction between soil texture and mineralogy (Table 3, Fig. 3d). Kaolinitic SCL had significantly weaker (0.43 kg·m^{-2}) crusts than SL soils with kaolinite (1.77 kg·m^{-2}) or quartz (1.92 kg·m^{-2}) (Fig. 3d).

Rainfall pattern effect on soil erosion in soils with different texture and mineralogy

No significant main or interaction effects on soil erosion were observed (Table 3). Nevertheless, IR treatment caused higher soil erosion than SR. Soil erosion was higher in SCL compared to SL. Equally, kaolinitic soils eroded more than quartz-dominated soils.

TABLE 3
Significance of texture, mineralogy and rainfall pattern effects on penetration resistance (PR), soil erosion (SE) and steady-state infiltration rate (SSIR)

Source	Nparm	DF	PR (kg·m^{-2})	SE (kg·m^{-2})	SSIR (mm·h^{-1})
			Prob > *F*	Prob > *F*	Prob > *F*
Replication	2	2	0.8113	0.7266	0.9859
Texture (T)	1	1	0.0039	0.5533	<.0001
Mineralogy (M)	1	1	0.0009	0.2481	<.0001
Rainfall pattern (RP)	1	1	0.0025	0.0877	<.0001
T × M	1	1	0.0061	0.0603	<.0001
T × RP	1	1	0.1586	0.9703	0.2694
M ×RP	1	1	0.657	0.9252	<.0001
T × M × RP	1	1	0.5044	0.7851	0.0075

Rainfall pattern effect on steady-state infiltration rate in soils with different texture and mineralogy

The SSIR was 10.57 mm·h^{-1} in SCL kaolinitic soils under IR compared to 4.68 mm·h^{-1} in SL kaolinitic soils. However, under the same rainfall pattern, SSIR was 2.99 mm·h^{-1} in SCL and 2.87 mm·h^{-1} in SL in quartz-dominated soils. Moreover, the dominance of quartz resulted in lower SSIR than for kaolinitic soil within the same rainfall pattern and texture class. In the SR treatment, SSIR was 5.79 mm·h^{-1} in kaolinitic SCL soils compared to 3.67 mm·h^{-1} in quartz-dominated SCL soils. Therefore, both IR and SR rainfall patterns reduced SSIR in SCL and SL quartz-dominated soils. However, SR caused higher SSIR (3.67 mm·h^{-1}) than SL (2.31 mm·h^{-1}) in quartz-dominated soils. Overall, IR/kaolinite/SCL interaction had the highest SSIR (10.57 mm·h^{-1}) compared to SR/quartz/SL treatment combination (2.31 mm·h^{-1}) (Fig. 4c).

DISCUSSION

Rainfall pattern effect on penetration resistance in soils with different texture and mineralogy

The IR rainfall pattern caused stronger crusts to develop on quartz-dominated soils compared to kaolinitic soils,

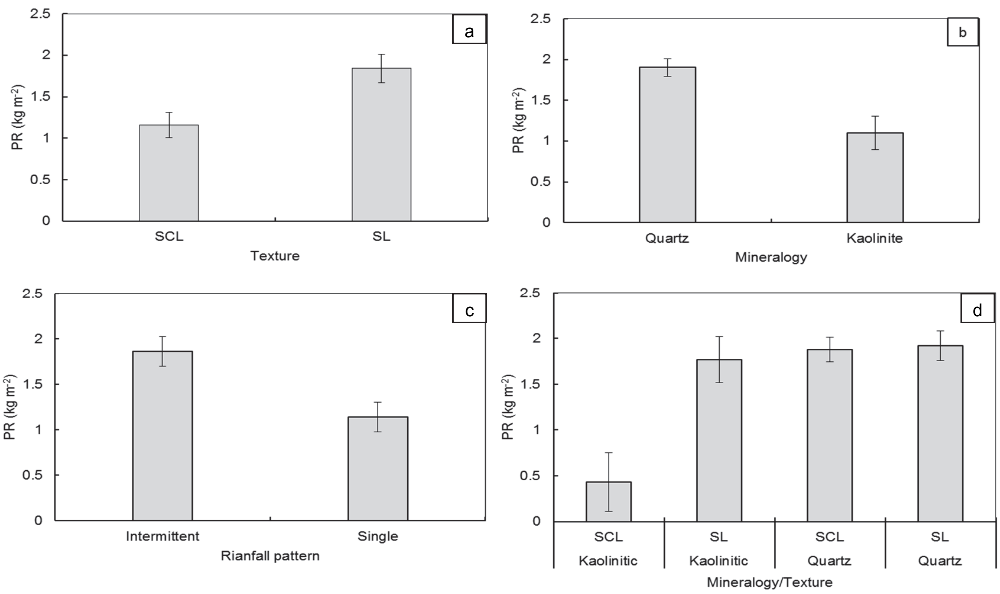

Figure 3
Effect of rainfall on crust strength in soils with different texture and mineralogy

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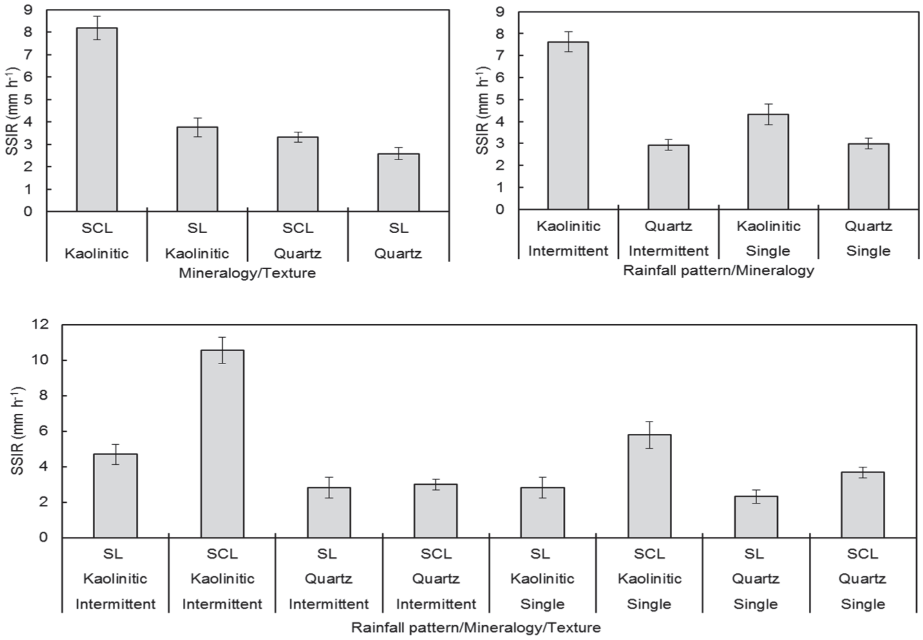

Figure 4
Effect of texture, mineralogy and rainfall pattern on steady-state infiltration rate (SSIR)

irrespective of the soil texture (Fig. 3d), but SR pattern led to higher crust strength for quartz-dominated than kaolinitic soils (Fig. 3b), as well as for SL than SCL soils (Fig. 3a).

The lower crust strength for SCL than SL soil could be due to high stability of the aggregates, which increased with an increase in clay content, as suggested by Kay and Angers (1999). Clay particles bind aggregates together thus contributing to cohesive strength of the aggregates, minimising breakdown upon wetting and thus reducing the tendency of the soil to crust (Levy and Mamedov, 2002). However, the results of this study showed higher crust strength in quartz-dominated soils than kaolinitic soils despite a similar soil texture (Fig. 3d). Therefore, we inferred that soil mineralogy was instrumental in crust formation in these soils. Kaolinitic soils are known to be less dispersive and highly stable (Stern et al., 1991; Wakindiki and Ben-Hur, 2002). On the other hand, primary minerals like quartz increase SOM mineralisation due to their inertness and low adsorption (Hassink, 1997; Buhman et al., 2006). Therefore, soils dominated by quartz should be highly dispersive. Nciizah and Wakindiki (2012) observed strong negative relationships (r = -0.74) between SOM and quartz in these soils. Such a relationship is an indication of poor aggregate stability and proneness to slaking on rapid wetting. However, the reason for increased soil crust strength after the intermittent rainstorm (Fig. 3c) is contentious. Some authors attribute increased crust strength to changes in the soil structure during the inter-storm period, whereby there is shrinking of clays upon drying which weakens cohesive forces within the crust on further wetting (Zhang and Miller, 1993; Rajaram and Erbach, 1999). Weaker crusts are more susceptible to breakdown during intermittent rainstorms, which is why they increase in strength upon drying (Zhang and Miller, 1993). In contrast, Levy et al. (1997) observed lower erosion for soil that had undergone an aging period of 18 h, because of densification and consolidation, which improved soil aggregate stability. However, within the mineralogy-rainfall pattern treatment combination, quartz-dominated soils resulted in a stronger crust than kaolinitic soils. Since quartz is inert and without charge it cannot bond with other soil materials like SOM; hence the high mineralisation of SOM (Buhman et al., 2006) in these soils. In the end, the soils are poorly aggregated resulting in a higher likelihood of breakdown upon wetting and hence crusting. As such, densification and consolidation which improves aggregation might not have taken place in these soils and hence the high crust strength with intermittent rainstorms. Therefore, it is possible that soils dominated by quartz develop higher strength during intermittent rainstorms as opposed to single storms, which allow soil restructuring and formation of stable aggregates. The latter could have been due to the longer uninterrupted aging period. Bajracharya and Lal (1999) showed that a longer drying period may increase the formation of new aggregates which reduces soil strength.

Rainfall pattern effect on soil erosion in soils with different texture and mineralogy

The non-significant differences in soil loss between intermittent rainstorms and the single rainstorm suggest that, for the soils used in this study, soil loss after one storm or several storms, if the total duration of the rain period is the same, is similar. This could be due to consolidation which resulted in increased stability with increasing wetting and drying cycles, as was the case in this study (Knapen, 2008). However, there could be differences in the distribution of the eroded sediment among the various storms, for the intermittent storms. The lack of difference in soil loss due to soil mineralogy could be due to the influence of smectite in the kaolinitc soils (Table 1). The slightest smectite has been shown to cause dispersion and breakdown and, subsequently, soil erosion, despite presence of the stable kaolinite (Stern et al., 1991). This could have rendered the kaolinitic soils equally susceptible to soil loss as the quartz-dominated soils. Similarly, there were no differences in soil loss between the SCL and SL soils. This could have been influenced by soil mineralogy, especially the smectite, which increased the breakdown of the otherwise stable kaolinitic soils as discussed previously.

Rainfall pattern effect on steady-state infiltration rate in soils with different texture and mineralogy

Steady-state infiltration rate was influenced by the interaction of rainfall pattern with soil texture and mineralogy (Table 3; Fig. 4). Intermittent rainstorms caused higher SSIR than the single rainstorm. However, kaolinitic SCL soils had higher SSIR than SL soils. This higher SSIR in SCL than SL within the intermittent rainfall for kaolinitic soils could be due to the high stability and non-dispersive nature of kaolinite (Wakindiki and Ben-Hur, 2002). Moreover, aggregate stability increases as clay increases, which improves infiltration rate (Boix-Fayos et al., 2001). Similar observations were reported by Erpul and Canga (1999). Likewise, Cattle et al. (2004) observed different crusting behaviour with rainfall pattern but concluded that aging of crusts through intermittent drying and wetting events had a greater potential for affecting the initially stable silty clay soil than the structurally unstable silty loam soil, unlike in the present study. They suggested that soil texture played a significant role in the crusting behaviours of soils. Conversely, in our study quartz seemed to have more influence on SSIR under intermittent rainfall than texture. Changing mineralogy from kaolinite to quartz reduced SSIR by more than 2 times for the SCL soils and more than 1.5 times for the SL soils. These findings propose that quartz supersedes other soil factors in decreasing SSIR. A plausible explanation for this observation is that soils dominated by quartz have low aggregate stability (Buhman et al., 2006), which possibly caused the soils to collapse, leading to low SSIR. Furthermore, quartz could probably have caused increased slaking and rearrangement of particles upon rapid wetting. Differences in crusting behaviour with rainfall pattern could also have been due to the method of formation of the crust, as suggested by Levy (1997). The author observed that infiltration recovery resulting from inter-storm restructuring was lower on seals caused by mechanical breakdown of aggregates and chemical dispersion than those produced by mechanical breakdown alone. Therefore, the higher SSIR after intermittent rainstorms compared to a single rainstorm could be due to a higher SSIR recovery.

CONCLUSIONS

Our study sought to determine the effect of single and intermittent rainstorms on such crust properties as strength and steady-state infiltration, and splash erosion for soils with different texture and mineralogy. Intermittent rainstorms resulted in higher crust strength, especially for quartz-dominated sandy loam soils. Such soils are dominant in the Eastern Cape Province; therefore, any changes in rainfall patterns that favour frequent rainstorms with numerous inter-storm drying periods are likely to increase soil crusting. Rainfall pattern, texture and mineralogy did not affect soil erosion for the soils used in this study, contrary to most reports, a result which, however, warrants further investigation. Reduction in SSIR was most influenced by such primary minerals as quartz, especially for coarser-textured soils, regardless of the rainfall type. Overall, quartz played an important role in influencing crusting and SSIR in these soils while clay and kaolinite reduced crusting and increased SSIR. Therefore, changes in rainfall pattern, to frequent intermittent or sporadic rainfall, will most likely lead to high crusting and low SSIR, due to the dominance of primary minerals in most parts of the Eastern Cape Province.

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