Data Article

Dataset on the use of the Soil Management Assessment Framework (SMAF) in evaluating the impact of conservation agriculture strategies on soil quality

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A R T I C L E   I N F O

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A B S T R A C T

This data article is a presentation of data related to the research article entitled "Crop rotation and residue management effects under no-till on the soil quality of a Haplic Cambisol in Alice, Eastern Cape, South Africa" (Gura and Mnkeni, 2019) [1]. A number of soil experimental techniques were used to acquire the soil indicators data and the data was interpreted using the Soil Management Assessment Framework (SMAF) to assess and quantify the impacts of conservation agriculture strategies on soil quality. The data was processed and analyzed using the JMP statistical package (SAS Institute Inc., 2013) [2]. The data is made available for further use and for furthering the understanding of the key findings of the related research.

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Specifications table

| Subject area       | Soil Science; Soil Fertility |
|--------------------|------------------------------|
| More specific subject area | Conservation agriculture impacts on soil quality |

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2352-3409 © 2019 Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
## Value of the data

- The data set is valuable in improving the understanding of CA dynamics in a South African context and its interpretation.
- The data provides the significance of using a soil quality evaluation tool in interpreting the impacts of conservation agriculture strategies.
- The data presents an insight for the efficient use of the Soil Management Assessment Framework (SMAF) by other researchers in studying South African soils and possibly other soils around the world.
- The SMAF algorithms that were used to generate data can be of use for further research by others who have interest in understanding soil quality on a broader scale.

## 1. Data

Table 1 shows the data on the interaction effects of crop rotations and residue management options on the soil chemical, physical and biological properties. Table 2 shows the data on the interaction effects of crop rotations and residue management options on the selected soil nutrient attributes. Table 3 shows the ANOVA results for soil quality assessment using the Soil Management Assessment Framework (SMAF) on the measured soil properties while Table 4 shows the soil quality assessment using the Soil Management Assessment Framework (SMAF).

## 2. Experimental design, materials, and methods

The data was generated from the analysis of the soil samples that were collected from a conservation agriculture trial. The experimental design for the treatments used was a split plot design. Standard soil extraction and analytical methods were used to generate the data. Bulk density ($\rho_b$) was determined using a coring method. Macro-aggregate stability (AGS) was measured using a method by Attou [3]. Soil pH was determined as outlined by AgriLASA [4]. Extractable P was determined by

The data was acquired by using soil standard methods in the laboratory and in the field on soils that were subjected to conservation agriculture strategies. Data was interpreted using Soil Management Assessment Framework (SMAF). The data was processed using JMP statistical package [2].

**Data format**

Processed

**Experimental factors**

Soil samples from a CA field trial laid out in a split plot design were used to determine the impacts of crop rotation and residue management and their interactions on soil quality.

**Experimental features**

Soil samples from a CA field trial were analyzed using standard soil methods in a laboratory as well as in the field and interpreted using Soil Management Assessment Framework (SMAF) algorithms to assess and quantify the impacts of the CA treatments on soil quality.

**Data source location**

Alice, Eastern Cape, South Africa; latitude 32°46’125 S and longitude 26°50’ E

**Data accessibility**

Data set is with this article

**Related research article**

Gura I and Mnkeni PNS, 2018, Crop rotation and residue management effects under no-till on the soil quality of a Haplic Cambisol in Alice, Eastern Cape, South Africa. [1]
extracting P in soils using the Olsen method as outlined in AgriLASA [4] and P concentrations were measured using the UV spectrophotometer. A method described by Okalebo [5] was used for measuring electrical conductivity (EC) of the soil samples. Extractable Na, K, Ca, and Mg were extracted using ammonium acetate as described by AgriLASA [4] and analyzed using an Inductively Coupled Plasma

Table 1
The data on interaction effects of crop rotations and residue management options on the soil chemical, physical and biological properties of the Haplic Cambisol at Alice, Eastern Cape, South Africa.

| Interactions | EC mS/cm | Soil pH | AGS (%) | \( \rho_b \) g/cm³ | SOC % | MBC mg/kg | BG activity |
|--------------|----------|---------|---------|----------------|------|-----------|-------------|
| 0–5 cm depth |          |         |         |                |      |           |             |
| R+ × MFM    | 224.43   | 5.74    | 15.2    | 1.62           | 1.36 | 240.0     | 295.8       |
| R+ × MFS    | 191.37   | 5.80    | 10.4    | 1.59           | 1.31 | 273.3     | 498.2       |
| R+ × MWS    | 162.50   | 5.83    | 10.4    | 1.56           | 1.58 | 226.3     | 311.5       |
| R+ × MWM    | 171.33   | 5.79    | 10.0    | 1.59           | 1.54 | 261.5     | 393.8       |
| R × MFM     | 189.97   | 5.79    | 7.00    | 1.60           | 1.21 | 190.3     | 297.8       |
| R × MFS     | 126.43   | 5.74    | 6.73    | 1.56           | 1.19 | 260.5     | 308.7       |
| R × MWS     | 147.09   | 5.81    | 6.93    | 1.63           | 1.21 | 208.2     | 360.8       |
| R × MWM     | 218.97   | 5.75    | 8.13    | 1.67           | 1.12 | 184.8     | 301.1       |
| 5–10 cm depth |        |         |         |                |      |           |             |
| R+ × MFM    | 139.37   | 5.77    | 10.0    | 1.62           | 1.44 | 141.9     | 267.6       |
| R+ × MFS    | 101.13   | 5.87    | 10.5    | 1.59           | 1.40 | 123.7     | 261.4       |
| R+ × MWS    | 69.30    | 5.97    | 9.47    | 1.56           | 1.40 | 186.1     | 267.7       |
| R+ × MWM    | 99.10    | 5.87    | 8.93    | 1.59           | 1.46 | 147.1     | 244.8       |
| R × MFM     | 88.57    | 5.90    | 7.00    | 1.60           | 1.07 | 111.7     | 208.7       |
| R × MFS     | 59.10    | 5.93    | 7.40    | 1.56           | 0.95 | 134.4     | 213.3       |
| R × MWS     | 68.83    | 5.92    | 6.73    | 1.63           | 1.08 | 120.8     | 216.1       |
| R × MWM     | 90.43    | 5.88    | 9.06    | 1.67           | 1.08 | 120.0     | 234.2       |

Symbols: EC – electrical conductivity; AGS – macro-aggregate stability; \( \rho_b \) – bulk density; SOC – soil organic carbon; MBC – soil microbial biomass; BG – beta-glucosidase activity. CA Treatments – MFM – maize-fallow-maize; MFS – maize-fallow-soybean; MWM – maize-wheat-maize; MWS – maize-wheat-soybean; R+ – residue retention; R – residue removal.

Table 2
The data on the interaction effects of crop rotations and residue management options on the selected soil nutrient attributes.

| Interactions | P mg/kg | K | Ca | Mg | Na | Fe |
|--------------|---------|---|----|----|----|----|
| 0–5 cm soil depth |         |   |    |    |    |    |
| R+ × MFM     | 65.2    | 692.7 | 1440.0 | 944.0 | 965.3 | 105.9 |
| R+ × MFS     | 56.7    | 690.0 | 1510.0 | 1018.0 | 978.7 | 105.0 |
| R+ × MWS     | 57.9    | 735.3 | 1894.7 | 1208.0 | 978.0 | 118.9 |
| R+ × MWM     | 64.9    | 784.0 | 1545.3 | 1066.0 | 980.0 | 93.2  |
| R × MFM      | 44.4    | 650.7 | 1009.3 | 892.7  | 946.7 | 87.9  |
| R × MFS      | 45.0    | 646.0 | 1257.3 | 974.7  | 939.3 | 48.2  |
| R × MWS      | 46.5    | 668.7 | 1370.0 | 988.0  | 1138.7 | 49.5 |
| R × MWM      | 54.4    | 668.0 | 1204.0 | 958.0  | 930.7 | 70.0  |
| 5–10 cm soil depth |         |   |    |    |    |    |
| R+ × MFM     | 49.4    | 167.3 | 798.7 | 168.7 | 317.3 | 135.2 |
| R+ × MFS     | 50.5    | 164.7 | 784.0 | 195.3 | 316.0 | 123.9 |
| R+ × MWS     | 38.1    | 163.3 | 802.7 | 210.7 | 330.7 | 118.6 |
| R+ × MWM     | 54.9    | 164.0 | 792.0 | 210.0 | 313.3 | 100.4 |
| R × MFM      | 31.5    | 168.0 | 688.0 | 151.3 | 303.3 | 63.4  |
| R × MFS      | 33.1    | 162.7 | 684.7 | 160.0 | 304.7 | 51.0  |
| R × MWS      | 33.2    | 166.0 | 750.7 | 182.0 | 305.2 | 49.3  |
| R × MWM      | 28.9    | 159.3 | 714.7 | 185.3 | 292.0 | 58.5  |

CA Treatments – MFM – maize-fallow-maize; MFS – maize-fallow-soybean; MWM – maize-wheat-maize; MWS – maize-wheat-soybean; R+ – residue retention; R – residue removal.
Emission Spectrometer (ICP-OES) (Varian 710-ES). Concentrations of extractable Fe were measured using ICP–OES (Varian 710-ES) after extracting soils with diethylenetriamine-pentaacetic acid (DTPA) as described by Whitney [6]. Total soil C (SOC) was determined in air-dried soil samples by dry combustion using the LECO (Truspec – CNS analyzer) [7]. Microbial biomass C was measured using standard soil fumigation and chemical extractions methods described by Brookes [8] and Vance [9]. β-glucosidase activity was measured based on methods described by Deng and Popova [10].

Table 3
ANOVA data for soil quality assessment using the Soil Management Assessment Framework (SMAF) on the measured soil properties and the soil quality index (SQI) of the Haplic Cambisol at Alice, Eastern Cape, South Africa.

| Treatment                     | SOC       | MBC       | BG activity | P | K | pH | EC | AGS | ρb |
|-------------------------------|-----------|-----------|-------------|---|---|----|----|-----|----|
| 0–5 cm depth                  |           |           |             |   |   |    |    |     |    |
| Residue Management            | *         | *         | ns          | ns| ns| ns | ns | *** | ns |
| Crop Rotations                | ns        | ns        | ns          | ns| ns| ns | ns | ns   | ns |
| Crop Rotation × Residue       | ns        | ns        | ns          | ns| ns| ns | ns | ns   | ns |
| Management                    |           |           |             |   |   |    |    |     |    |
| 5–10 cm depth                 |           |           |             |   |   |    |    |     |    |
| Residue Management            | ***       | ns        | ns          | ns| ns| ns | ns | ns   | ns |
| Crop Rotations                | ns        | ns        | ns          | ns| ns| ns | ns | ns   | ns |
| Crop Rotation × Residue       | ns        | ns        | ns          | ns| ns| ns | ns | ns   | ns |

Symbols: EC – electrical conductivity; AGS – macro-aggregate stability; ρb – bulk density; SOC – soil organic carbon; MBC – soil microbial biomass; BG – beta-glucosidase activity; SQI – soil quality index; ns – Treatment not significant at P = 0.05 probability level; * – Treatment significant at p = 0.05 probability level; ** – Treatment significant at p = 0.01 probability level; *** – Treatment significant at p = 0.001 probability level.

Table 4
The data for the soil quality assessment using the Soil Management Assessment Framework (SMAF): mean indicator scores and the Soil Quality Indexes (SQI) of the interaction treatments. A score of 1.0 represents optimum value of the indicator performance.

| Interactions   | Soil quality indicators | SQI (%) |
|----------------|-------------------------|---------|
|                | SOC         | MBC      | BG activity | P | K | soil pH | EC | AGS | ρb |
| 0–5 cm soil depth |           |           |             |   |   |         |    |     |    |
| R+ × MFM       | 0.97       | 1.00      | 1.00        | 1.00| 1.00| 0.79    | 1.00| 0.63| 0.40| 86.7 |
| R+ × MFS       | 0.96       | 1.00      | 1.00        | 1.00| 1.00| 0.87    | 1.00| 0.52| 0.43| 86.2 |
| R+ × MWS       | 0.99       | 0.99      | 1.00        | 1.00| 1.00| 0.85    | 1.00| 0.52| 0.48| 87.0 |
| R+ × MWM       | 0.99       | 1.00      | 1.00        | 1.00| 1.00| 0.82    | 1.00| 0.51| 0.42| 86.0 |
| R- × MFM       | 0.94       | 0.99      | 1.00        | 1.00| 1.00| 0.81    | 1.00| 0.44| 0.43| 84.3 |
| R- × MFS       | 0.93       | 1.00      | 1.00        | 1.00| 1.00| 0.76    | 1.00| 0.43| 0.46| 84.1 |
| R- × MWS       | 0.94       | 0.99      | 1.00        | 1.00| 1.00| 0.83    | 1.00| 0.44| 0.40| 84.1 |
| R- × MWM       | 0.90       | 0.99      | 1.00        | 1.00| 1.00| 0.79    | 1.00| 0.47| 0.34| 83.1 |
| 5–10 cm soil depth |           |           |             |   |   |         |    |     |    |
| R+ × MFM       | 0.98       | 0.88      | 1.00        | 1.00| 0.85| 0.81    | 1.00| 0.51| 0.40| 82.6 |
| R+ × MFS       | 0.98       | 0.80      | 1.00        | 1.00| 0.84| 0.88    | 1.00| 0.52| 0.43| 82.8 |
| R+ × MWS       | 0.98       | 0.99      | 1.00        | 1.00| 0.84| 0.93    | 1.00| 0.50| 0.48| 85.7 |
| R+ × MWM       | 0.98       | 0.88      | 1.00        | 0.99| 0.84| 0.89    | 1.00| 0.49| 0.42| 83.3 |
| R- × MFM       | 0.88       | 0.76      | 1.00        | 1.00| 0.85| 0.88    | 1.00| 0.44| 0.43| 80.2 |
| R- × MFS       | 0.78       | 0.86      | 1.00        | 1.00| 0.84| 0.91    | 1.00| 0.45| 0.46| 81.0 |
| R- × MWS       | 0.88       | 0.83      | 1.00        | 1.00| 0.85| 0.90    | 1.00| 0.43| 0.40| 80.6 |
| R- × MWM       | 0.88       | 0.80      | 1.00        | 1.00| 0.83| 0.87    | 1.00| 0.49| 0.34| 79.9 |

Symbols: SOC – soil organic carbon; MBC – soil microbial biomass; BG – beta-glucosidase activity; EC – electrical conductivity; AGS – macro-aggregate stability; ρb – bulk density; SQI – soil quality index. CA Treatments – MFM – maize-fallow-maize; MFS – maize-fallow-soybean; MWM – maize-wheat-maize; MWS – maize-wheat-soybean; R+ – residue retention; R- – residue removal.

Emission Spectrometer (ICP–OES) (Varian 710-ES). Concentrations of extractable Fe were measured using ICP–OES (Varian 710-ES) after extracting soils with diethylenetriamine-pentaacetic acid (DTPA) as described by Whitney [6]. Total soil C (SOC) was determined in air-dried soil samples by dry combustion using the LECO (Truspec – CNS analyzer) [7]. Microbial biomass C was measured using standard soil fumigation and chemical extractions methods described by Brookes [8] and Vance [9]. β-glucosidase activity was measured based on methods described by Deng and Popova [10].
Soil Management Assessment Framework scoring algorithms developed by Andrews [11] were used on relevant soil indicators to interpret the data generated from soil analysis. The data generated using the SMAF was processed statistically using JMP statistical package [2].

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Transparency document. Supplementary material

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