SOIL ORGANIC CARBON DYNAMICS IN A DRYLAND WHEAT- FALLOW SYSTEM: DAYCENT MODEL SIMULATIONS

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INTRODUCTION

- Cultivation of winter wheat (*Triticum aestivum* L.)-summer fallow (WW-SF) has caused rapid decline in soil organic carbon (SOC) in Pacific Northwest (PNW).
- Agricultural management practices such as organic matter and fertilizer addition, and crop residue management can increase soil carbon sequestration and enhance the long-term productivity of soil.
- We used DAYCENT model to simulate the impact of various crop residue and nutrient management practices on SOC content, and grain and residue yield in a long-term (>80 years) WW-SF system at Columbia Basin Agriculture Research Center near Pendleton, OR.

OBJECTIVES

- To evaluate the performance of DAYCENT model in predicting changes in SOC .
- To estimate SOC change since 1931 to 2010 and project the potential change over next seven decades in response to different management practices.

MATERIALS AND METHODS

- Study site : Columbia Basin Agricultural Research Center near Pendleton, OR.
- Latitude and longitude: 45º42'N, 118º36'W
- Climate: Semiarid temperate, average annual precipitation 421 mm.
- Soil type: Walla Walla silt loam (coarse-silty, mixed, superactive, mesic Typic Haploxerolls).
- Cropping system: Winter wheat- summer fallow system
- Treatments : Fall burning of crop residue (FB0), no burning of cop residue with 0 (NB0), 45 (NB45) and 90 (NB90) kg N ha^{-1}, and addition of cattle manure (MN) and pea vines (PV).
- Years under current management : >80 (1931- present).
- Experimental design: An ordered arrangement of two series (1400 and 1500) with two replicates
- Plot size: 11.6 m × 40.2 m

DAYCENT MODEL

- DAYCENT model (Del Grosso et al., 2001; Parton et al., 1998) is the daily time step version of the CENTURY model which simulate carbon, nitrogen and phosphorous dynamics for grassland, savanna, cropland and forest ecosystems.
- The model input variables include
  - Weather variables (daily maximum and minimum temperature; daily precipitation)
  - Soil variables (soil texture, bulk density, pH, soil thickness etc.)
  - Land use history
  - Plant information (crop type, rooting depth, harvest index etc.)
  - Management information (Tillage, fertilizer etc.)
- The agreement between model and measured data is shown in Fig.1.
- The accuracy of model prediction was estimated using various statistics (Table 2 and Fig. 2)

RESULTS AND DISCUSSIONS

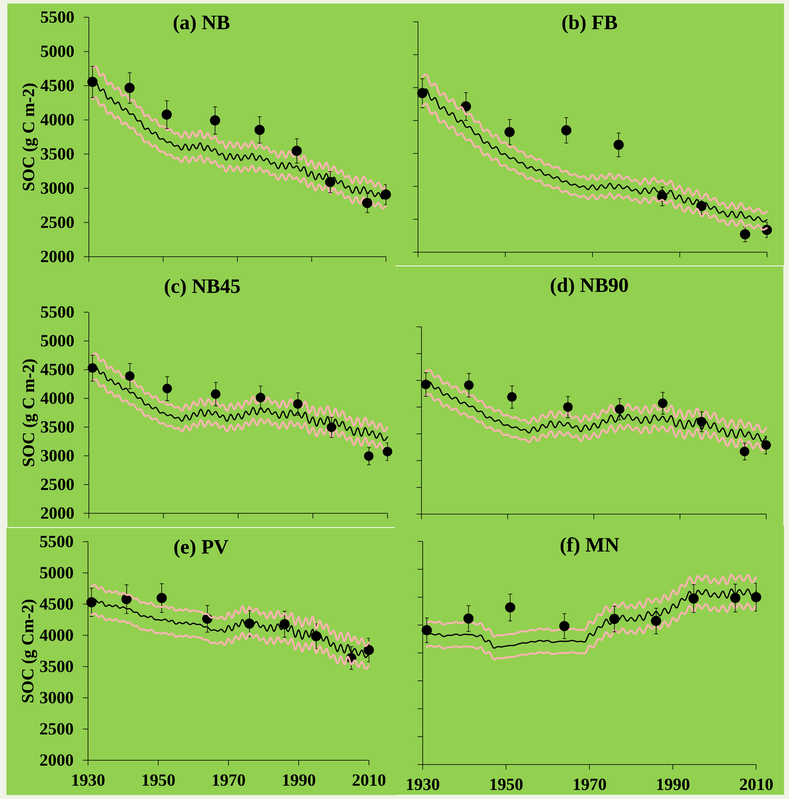

Fig. 1. Comparison of observed (symbols) and simulated (lines) soil C (0-30 cm) in different treatments. Model means (black lines) and its 95% confidence intervals also provided.

- The DAYCENT model predicted well the relative magnitude of change in C content and its direction for all treatments.
- Observed values were within the 95% confidence interval of the simulated values 66% to 89% of the time based on treatment.

Table 2. Statistics* describing the performance of DAYCENT.

Trt	RMSE (g C m^{-2})	NRMSE (%)	EF	E (%)	M (g C m^{-2})	t-test	r
NB0	278	7.51	3.94	4.59	570	S	0.95
FB0	381	11.4	3.04	3.75	527	NS	0.90
NB45	268	6.96	2.71	1.40	250	NS	0.89
NB90	291	7.42	1.09	3.17	433	NS	0.81
PV	146	3.47	4.08	1.56	212	NS	0.92
MN	274	5.80	-0.37	2.24	312	NS	0.71

*Root mean square (RMSE), normalized RMSE (NRMSE), modeling efficiency (EF), relative error (E), mean difference (M), and correlation coefficient (r)

- The low values for RMSE, NRMSE, E and M indicated good agreement between observed and model results.
- High r suggested the simulated values follow the same pattern as observed values.
- Paired t-test results revealed no significant bias between observed and simulated SOC values for all treatments except NB0.

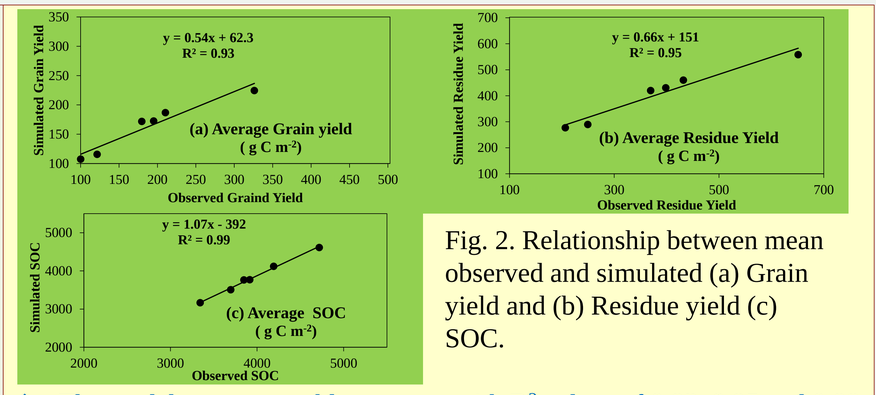

Fig. 2. Relationship between mean observed and simulated (a) Grain yield and (b) Residue yield (c) SOC.

- The model was reasonably accurate with R^2 values of 0.93, 0.95 and 0.99 for the mean of observed and modeled grain yield, residue yield and SOC, respectively.

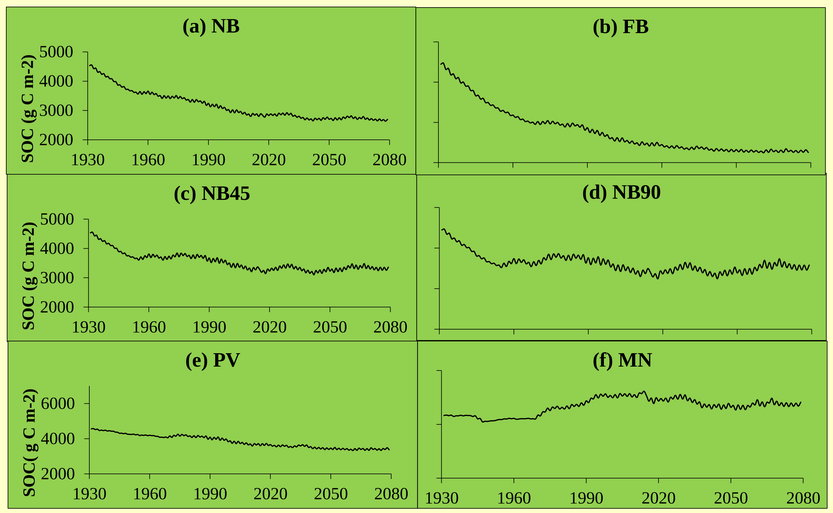

Fig. 3. Predicted SOC until 2080 by DAYCENT model.

- DAYCENT showed highest rate of SOC decrease in FB0 (25 g C m^{-2} yr^{-1}) and an increase in MN (10 g C m^{-2} yr^{-1}) from 1931 to 2010, similar to the observed values.
- The model projected SOC loss between 866 to 2192 g C m^{-2} for WW-SF systems except MN, which is expected to gain 496 g C m^{-2} SOC from 1931 to 2080.
- The forecast however, indicated that gain in SOC in MN reaches its maximum capacity by 2014, slightly declines until 2018 and stays in a steady state thereafter.

CONCLUSIONS

- DAYCENT model produced reasonably accurate simulation of SOC, grain and residue yield.
- Model prediction suggested that SOC continues to decline in all WW-SF systems, except for MN.
- Crop residue burning or application of inorganic fertilizers alone will not maintain SOC in dryland WW-SF system and support the long-term agricultural sustainability.

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