Short-term Crop Sequence Effects on Soil Properties

Synopsis of Results

2003 and 2004 Cropping Seasons

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Context

- Understanding the effects of alternative crops on soil properties is essential to develop sustainable dryland cropping systems.

- Crop effects on surface soil properties, in particular, are vitally important given the impact the soil surface has on erosion control, water infiltration, and nutrient conservation.

Objective

- An evaluation was conducted to assess short-term crop sequence effects on soil properties within a crop by crop residue matrix experiment near Mandan, ND.

- Assessments of soil properties were limited to crop sequences where corn was planted during the second year of the matrix.

Approach

Sampling Protocol:

- Soil samples were collected in 2002 and 2003 prior to planting the matrix, and again in 2003 and 2004 prior to planting corn.
- Samples were collected using a hand probe from three depths: 0-5, 5-10, and 10-20 cm.
- In-field measurements of soil temperature and volumetric water content were made during the growing season.

Approach

Analyses:

- Samples were analyzed for various soil physical, chemical, and biological properties.

- Results were evaluated by comparing crop effects within a year and over time.

Soil bulk density, pH, and NO_3-N

- Soil bulk density refers to the mass of a unit volume of dry soil. Factors that affect soil pore space will affect bulk density.
- Soil pH is a measure of the acidity or alkalinity of the soil solution. In general, pH values between 6.0 and 7.5 are optimal for crop growth.
- Soil nitrate is an anion (NO_3^-). In this form, it is most readily taken up by plants, but also easily lost by leaching.

Soil bulk density, pH, and NO_3-N

2003, Field H3

- Crop sequence effects on soil properties were limited to the 0-5 cm depth.

- At 0-5 cm, changes in soil properties over time (1 yr) occurred under the following crops:
  - Grain sorghum: Soil bulk density increased from 0.95 to 1.03 g/cm^3 between 2002 and 2003.
  - Spring wheat: Soil pH increased from 6.30 to 6.48 between 2002 and 2003.

Soil bulk density, pH, and NO_3-N

2003, Field H3, 0-5 cm

Previous crop	Soil bulk density g/cm3	Soil pH -log[H+]	Soil nitrate kg N/ha
Buckwheat	0.99	6.20	6.3
Canola	1.03	6.47	8.8
Chickpea	0.99	6.19	5.7
Corn	1.02	6.07	9.5
Dry pea	1.12	6.07	8.1
Lentil	1.07	6.90	6.7
Millet	1.04	6.11	5.7
Sorghum	1.03	6.27	3.9
Sunflower	0.92	6.28	6.8
Spring wheat	1.03	6.48	9.6
LSD (0.05)	*0.08*	*NS*	*NS*
P-value	*0.0113*	*0.0891*	*0.1373*

= Highest value = Lowest value

Soil bulk density, pH, and NO_3-N

2004, Field I7

- Similar to field H3, crop sequence effects on soil properties were limited to the 0-5 cm depth.

- At 0-5 cm, changes in soil properties over time (1 yr) occurred under the following crops:
  - Dry pea, Sunflower: Soil pH decreased by 0.15 and 0.50 pH units, respectively, between 2003 and 2004.
  - Canola, Chickpea, Dry pea, Sorghum, and Spring wheat: Soil NO_3-N decreased by 11, 7, 6, 15, and 10 kg N/ha, respectively, between 2003 and 2004.

Soil bulk density, pH, and NO_3-N

2004, Field I7, 0-5 cm

Previous crop	Soil bulk density g/cm3	Soil pH -log[H+]	Soil nitrate kg N/ha
Buckwheat	1.16	5.96	7.3
Canola	1.10	6.02	5.5
Chickpea	1.04	6.15	4.6
Corn	1.04	5.66	5.9
Dry pea	1.06	5.99	4.6
Lentil	1.09	6.18	8.1
Millet	1.14	5.88	8.9
Sorghum	1.15	5.88	5.4
Sunflower	1.04	5.68	9.2
Spring wheat	1.08	6.07	2.8
LSD (0.05)	*NS*	*NS*	*3.7*
P-value	*0.1973*	*0.0599*	*0.0278*

= Highest value = Lowest value

Soil bulk density, pH, and NO_3-N

- Soil bulk density was affected by previous crop, though all values were ideal for crop growth.
- Previous crop did not affect soil pH.
- Nitrate levels were greatest following sunflower, and least following spring wheat. Root distribution in near-surface soil depths may have contributed to differences in N uptake.

Soil Temperature and Water Content

- Soil temperature and water content affects numerous physical, chemical, and biological processes, and thereby the growth of plants.
- Soil temperature is important early in the growing season, as it can impact nutrient and water uptake by young plants.
- Retention of soil water in near-surface depths is affected by soil texture, structure, and organic matter content.

Soil Temperature – 2003 (Field H3)

Measured in row at 2.5 inch depth

Previous Crop	- - - - - - - - - - - - Day of year - - - - - - - - - - - -				
	157	167	170	174	177
Buckwheat	17.6	28.2	26.6	24.5	20.7
Canola	17.7	27.9	26.4	25.2	21.5
Chickpea	17.4	27.5	25.4	24.2	20.7
Corn	17.1	26.5	25.6	24.9	21.4
Dry pea	17.4	28.4	26.4	25.4	20.9
Lentil	17.7	26.5	26.8	25.3	21.5
Millet	17.2	26.6	25.2	24.6	21.2
Sorghum	17.3	26.1	25.0	24.2	20.8
Sunflower	17.7	26.9	26.2	24.7	21.0
Spring wheat	17.6	27.4	25.3	24.3	20.8
LSD (0.05)	*0.3*	*1.3*	*0.9*	*0.6*	*NS*
P-value	*<0.0001*	*0.0044*	*<0.0001*	*0.0005*	*0.3077*

= Highest value = Lowest value

Soil Water Content – 2003 (Field H3)

Measured in row at 0-5 inch depth

Previous Crop	- - - - - - - - - - - - - - Day of year - - - - - - - - - - - - - -				
	157	167	170	174	177
Buckwheat	46.3	37.2	31.0	27.1	38.7
Canola	55.4	44.2	37.0	36.1	45.2
Chickpea	49.0	41.7	36.6	35.8	40.0
Corn	50.1	40.9	34.2	32.3	43.3
Dry pea	48.3	40.3	37.3	33.2	42.9
Lentil	57.3	51.2	42.8	39.3	45.1
Millet	49.8	38.6	34.8	29.6	44.1
Sorghum	55.4	40.1	32.9	31.1	44.2
Sunflower	49.3	39.1	33.9	27.9	43.3
Spring wheat	53.6	40.8	38.3	33.1	47.9
LSD (0.05)	*NS*	*7.2*	*6.4*	*5.8*	*NS*
P-value	*0.0837*	*0.0192*	*0.0385*	*0.0014*	*0.9410*

= Highest value = Lowest value

Soil Temperature – 2004 (Field I7)

Measured in row at 2.5 inch depth

Previous Crop	Day of year						
	155	165	169	176	183	190	197
Buckwheat	20.7	23.2	21.4	20.9	26.2	24.8	28.7
Canola	20.8	23.4	21.3	22.0	26.5	24.1	30.4
Chickpea	21.2	24.6	22.2	21.6	26.7	25.1	29.9
Corn	21.1	24.1	21.8	23.1	26.5	24.4	29.8
Dry pea	21.2	24.2	21.6	22.7	26.4	24.9	29.6
Lentil	21.0	24.4	22.2	23.8	27.3	25.1	29.5
Millet	20.4	23.1	21.2	22.3	26.2	24.3	28.8
Sorghum	20.4	23.0	21.4	22.9	26.2	24.3	29.7
Sunflower	21.4	24.4	22.4	22.9	27.0	24.7	29.6
Spring wheat	20.7	23.1	21.7	22.3	25.9	24.5	28.8
LSD (0.05)	*0.4*	*0.9*	*0.7*	*NS*	*0.6*	*0.7*	*1.0*
P-value	*<0.0001*	*0.0002*	*0.0022*	*0.3577*	*0.0002*	*0.0238*	*0.0078*

= Highest value = Lowest value

Soil Water Content – 2004 (Field I7)

Measured in row at 0-5 inch depth

Previous Crop	Day of year						
	155	165	169	176	183	190	197
Buckwheat	29.3	38.8	37.3	27.4	55.4	47.3	21.8
Canola	31.8	44.6	36.7	29.8	54.5	44.1	29.6
Chickpea	26.8	33.8	37.8	24.9	48.8	36.9	21.5
Corn	32.7	38.8	37.7	27.3	52.0	40.3	21.1
Dry pea	23.8	33.8	32.1	22.3	44.9	37.3	19.6
Lentil	27.4	41.2	37.0	24.6	54.2	42.3	20.2
Millet	36.5	51.4	42.6	29.5	58.2	45.8	21.8
Sorghum	31.8	41.2	37.6	29.3	53.0	43.3	22.5
Sunflower	31.2	42.1	37.2	26.5	60.4	41.1	21.8
Spring wheat	28.8	41.8	36.4	29.3	49.3	45.6	22.5
LSD (0.05)	*4.8*	*5.8*	*NS*	*4.1*	*7.4*	*5.4*	*4.0*
P-value	*<0.0001*	*<0.0001*	*0.1866*	*0.0041*	*0.0032*	*0.0015*	*0.0004*

= Highest value = Lowest value

Soil Temperature and Water Content

- Near-surface soil temperature and water content were strongly affected by previous crop.
- Early season soil temperature tended to be greatest following lentil and sunflower.
- Crop effects on soil water content were not consistent between years due to differences in growing conditions.

Conclusions

- Crop sequence effects on soil properties were relatively modest within the short timeframe of the study.
- Early season soil temperature and water content were strongly influenced by crop sequence. Soil temperature within lentil and sunflower tended to be greater than other crops. Trends among crops in soil water content differed by growing season.