Long-Term Tillage Effects on Soil Organic Carbon, Nitrogen, and Grain Yields of Winter Wheat – Spring Pea Rotation in the Pacific Northwest

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RATIONALE

- ❑ Soil organic C sequestration and N storage enhance soil health and sustainable agricultural production, as well as, offset anthropogenic CO_2 and N_2O emissions from agroecosystems.
- ❑ Tillage influences residue distribution and regulates soil micro-environment that can alter SOC and N dynamics, and crop productivity.
- ❑ Long-term studies could be an efficient way to assess the role that tillage systems play in SOC and N dynamics, and agricultural productivity.

AIM

- ❑ Determine long-term (47-year) tillage influences on
  1. SOC and TN within 60 cm soil profile,
  2. Bulk density and pH at different depth intervals,
  3. Grain yields of wheat and pea in a two-year rotation.
- ❑ Compare the soil quality parameters against that of an undisturbed grass pasture, and report the status of SOC and TN over time.

STUDY

- ❑ Site: Columbia Basin Agricultural Research Center near Pendleton, OR (45º42' N, 118º35' W). The wheat-pea experiment established in 1963.
- ❑ Soil type: Walla Walls silt loam (coarse-silty, mixed, mesic Typic Haploxeroll), 0-1% slope.
- ❑ Climate: Semiarid temperate, 418 mm average annual precipitation.
- ❑ Crop rotation: 2 year winter wheat – spring pea
- ▪ *Wheat phase*: Semi-dwarf soft white winter wheat planted in fall (early October), harvested between June and July.
- ▪ *Pea phase:* Spring dry-edible pea sown in (March to early April), harvested in June.
- ❑ Experimental design: Split-plot – crop whole plots and tillage sub plots (4 replications).
- ❑ Reference site: Grass pasture of native vegetation since 1931, no disturbance and external inputs.
- ❑ In 2010, soils analyzed for pH, bulk density, SOC and N.
- ❑ Grain yields determined for the years 2005 to 2010.

Table 1. Tillage treatments in the study

Treatments	Primary Tillage			
	After Wheat Stubble	Depth (cm)	After Pea Vines	Depth (cm)
Fall Plow	Moldboard Plow (fall)	20	Moldboard plow (fall)	20
Spring Plow	Moldboard Plow (spring)	20	Moldboard plow (fall)	20
Disk/Chisel	Disk (fall)	10	Chisel (fall)	20
No-till (since 1996)	No-till	-	No-till	-

SOIL PARAMETERS

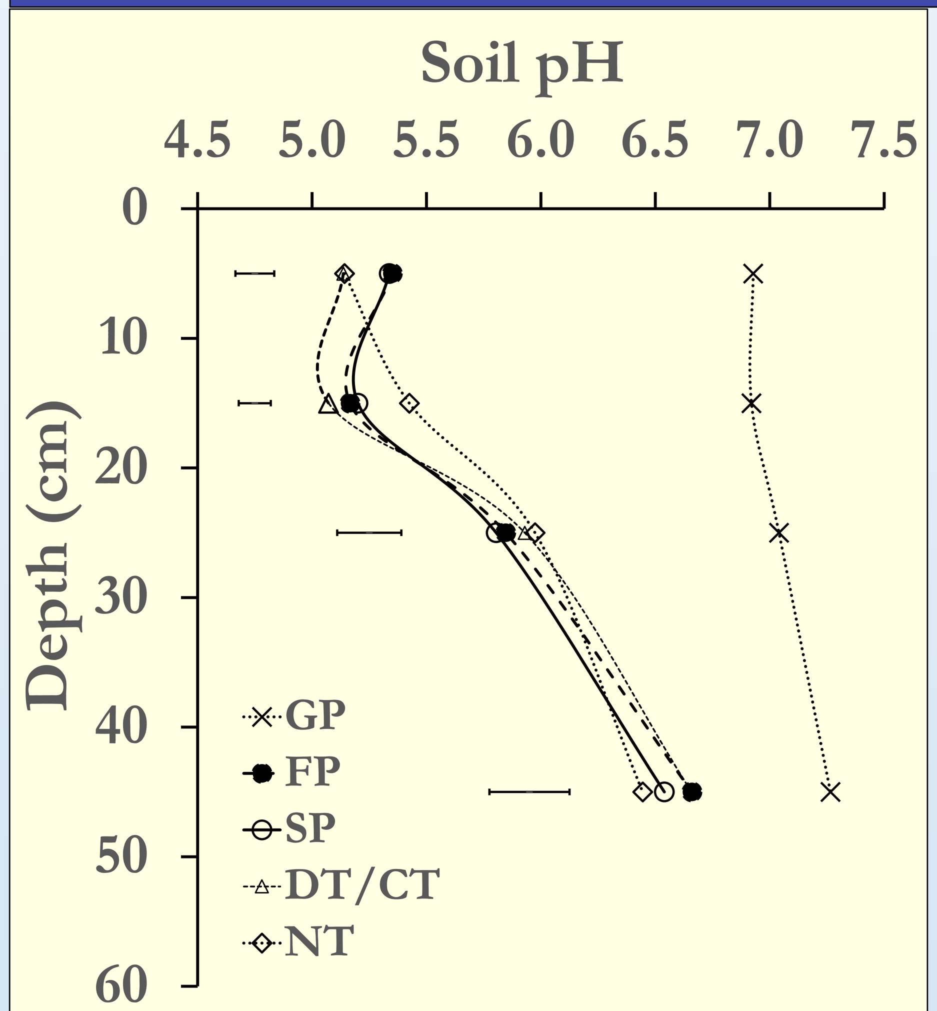

Fig. 1. Soil profile pH under tillage systems in 2010. Tukey's HSD values (bars) shown for significant ($P \leq 0.05$) soil layers. GP, grass pasture; FP, fall plow; SP spring plow; DT/CT, disk and chisel; NT, no-till

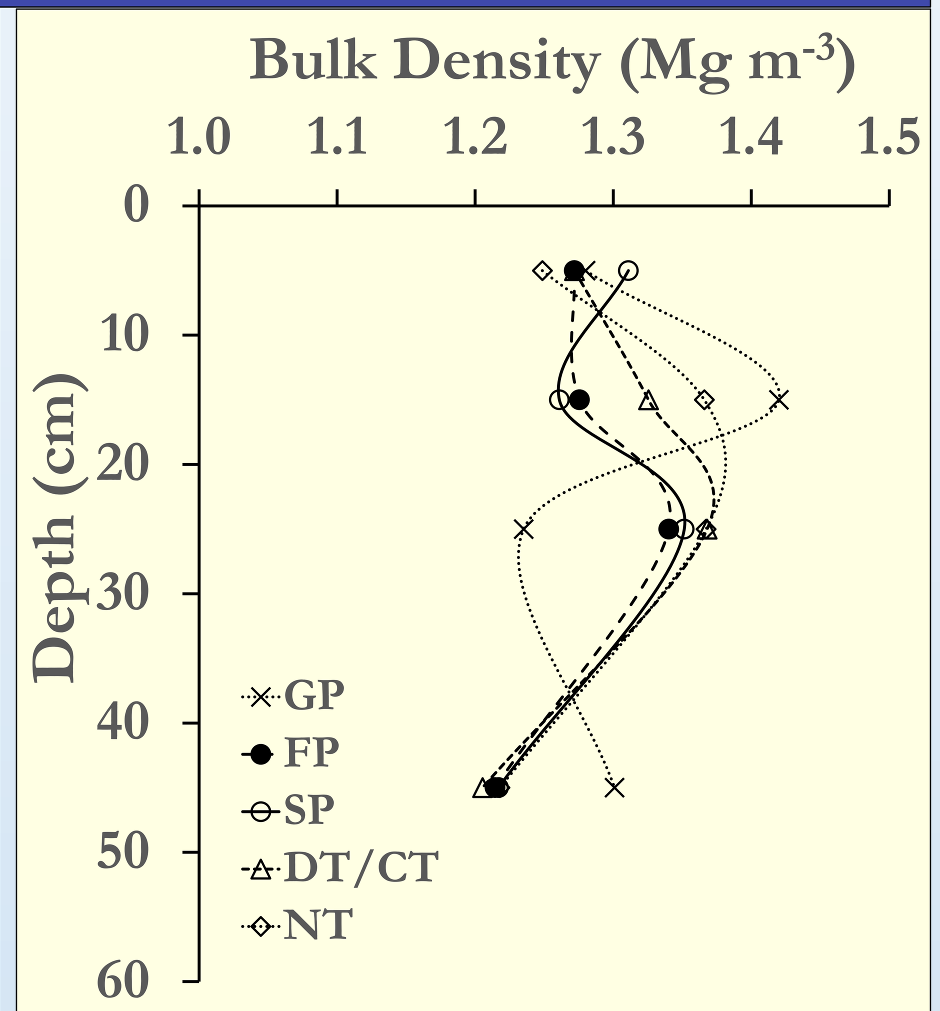

Fig. 2. Bulk density under tillage systems in 2010. Tukey's HSD values (bars) shown for significant ($P \leq 0.05$) soil layers. GP, grass pasture; FP, fall plow; SP spring plow; DT/CT, disk and chisel; NT, no-till

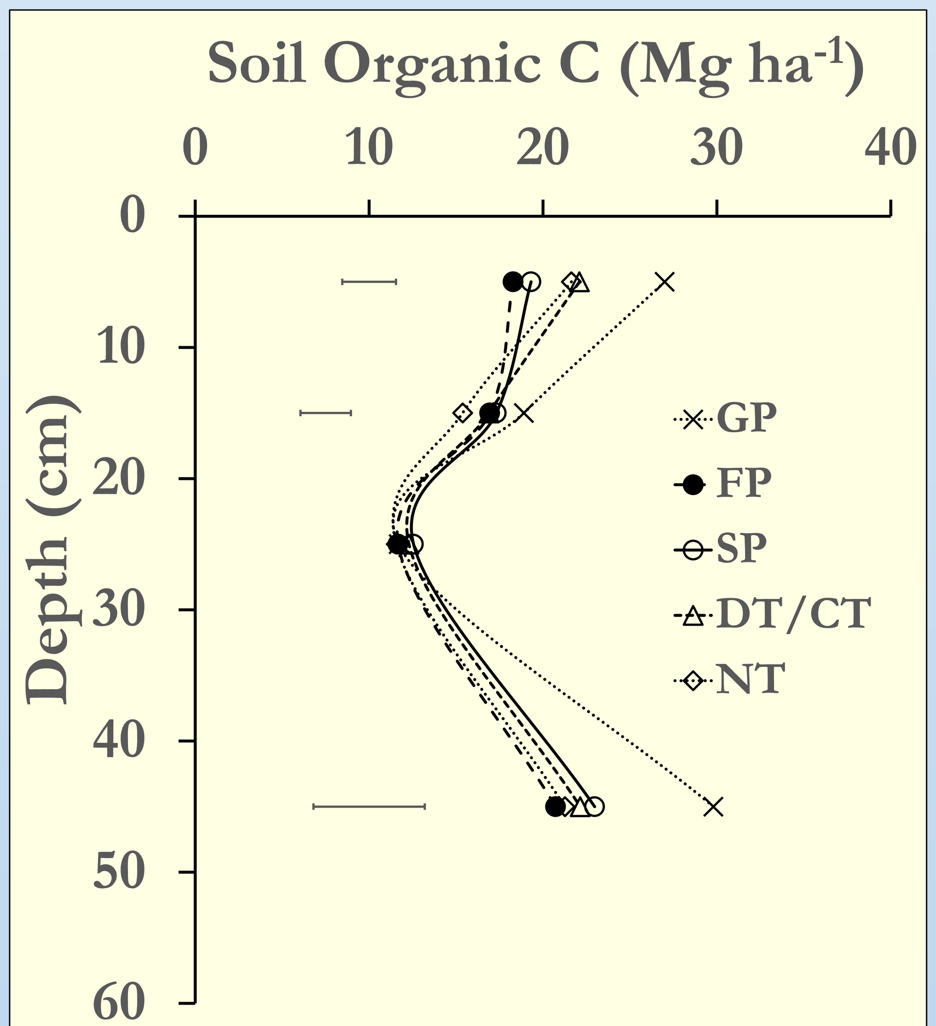

Fig. 3. Soil organic C under tillage systems in 2010. Tukey's HSD values (bars) shown for significant ($P \leq 0.05$) soil layers. GP, grass pasture; FP, fall plow; SP spring plow; DT/CT, disk and chisel; NT, no-till

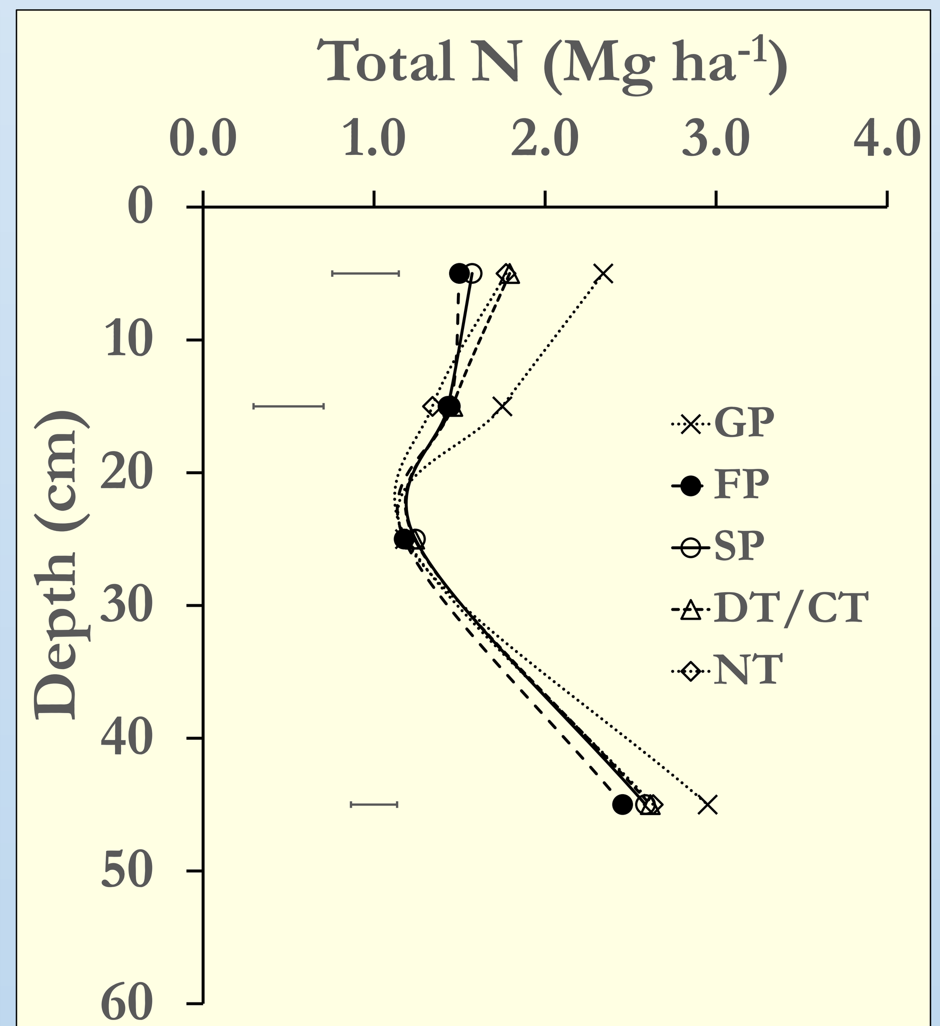

Fig. 4. Total N under tillage systems in 2010. Tukey's HSD values (bars) shown for significant ($P \leq 0.05$) soil layers. GP, grass pasture; FP, fall plow; SP spring plow; DT/CT, disk and chisel; NT, no-till

Table 2. Changes in soil organic C and total N in whole 60 cm profile

Tillage	Soil Organic C			Total N		
	1995	2010	(1995-2010)‡	1995	2010	(1995-2010)‡
	Mg ha^{-1}		%	Mg ha^{-1}		%
Grass Pasture	-	87.4 a	-	-	8.22 a	-
Fall Plow	65.9 a	67.6 c	2.6^{ns}	6.55 a	6.57 c	0.3^{ns}
Spring Plow	65.9 a	72.2 b	9.5*	6.58 a	6.84 bc	3.9*
Disk/Chisel	65.5 a	73.4 b	12.1*	6.56 a	7.10 b	8.3*
No-till	64.3 a	69.8 bc	8.6*	6.37 a	6.93 bc	8.8*

Means with different letters within a column in each year are different at α = 0.05. ‡The columns compare SOC and TN across years. * indicates that SOC and TN means in 1995 and 2010 are significantly different at α = 0.05. ns indicate not significant. The 1995 data was obtained from Machado, 2011.

CROP YIELDS

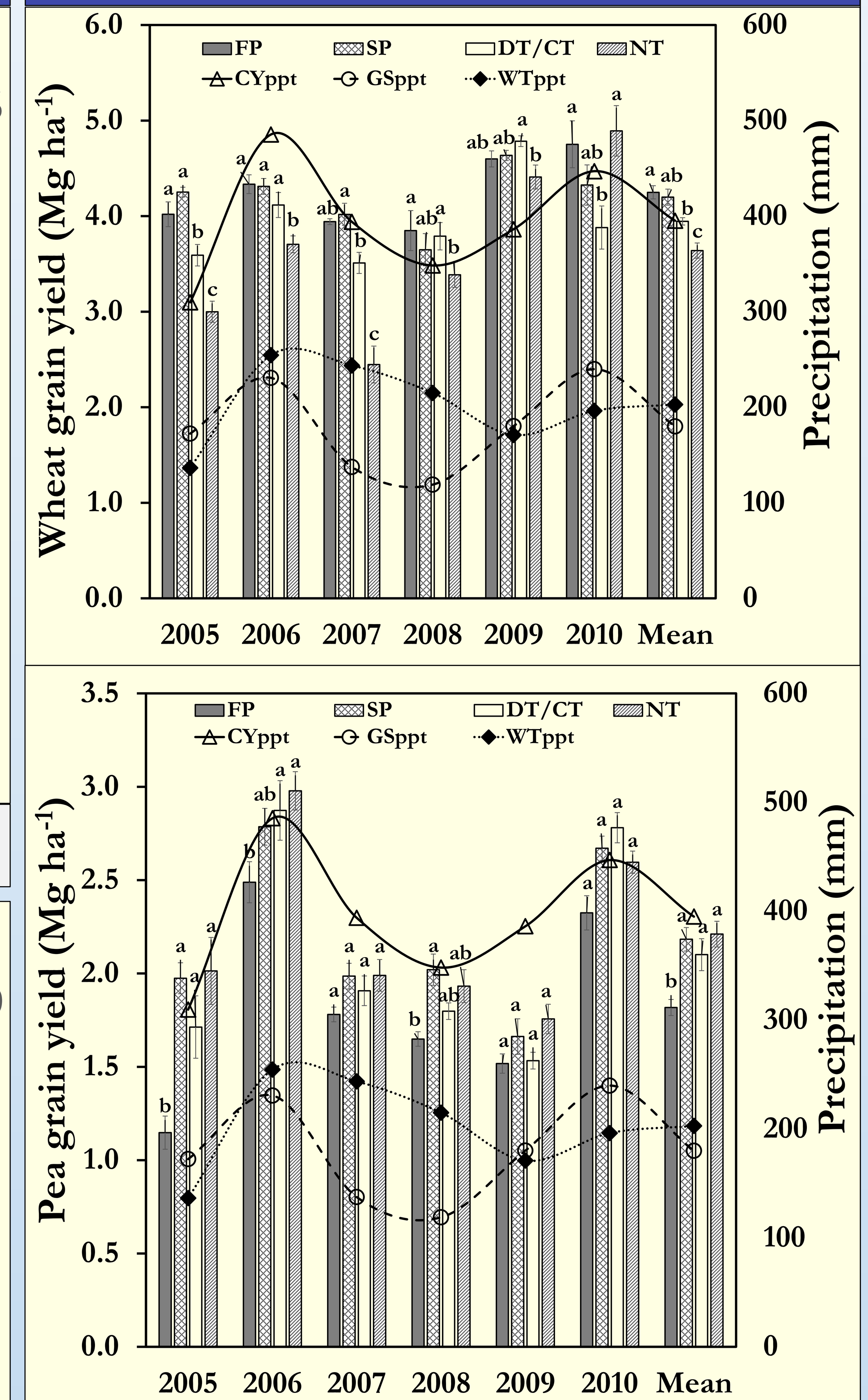

Fig. 5. Grain yields of wheat (above) and pea (below) under tillage systems. Means with different letters within each year are different at α = 0.05. FP, fall plow; SP spring plow; DT/CT, disk and chisel; NT, no-till; CYppt, crop-year precipitation (Sept-Aug); WTppt, winter precipitation (Sept-Feb); and GSppt, growing season precipitation (March-July).

SUMMARY

- ❑ Conversion of native grassland to wheat-pea cropping system remarkably declined soil pH, SOC, and TN.
- ❑ Conservation tillage cropping systems increased SOC and TN relative to fall plowing, with greater storages observed near soil surface (0-10 cm).
- ❑ No-till would probably require more time to build-up SOC and TN.
- ❑ Conservation tillage systems increased pea yield over fall plowing, but wheat yields may be constrained due to poor weed control without plowing.
- ❑ Effective weed control along with reductions in tillage and N-fertilizer associated costs will likely result in greater adoption of conservation tillage systems in the Pacific Northwest.

REFERENCES

- Machado, S. 2011. Soil organic carbon dynamics in the Pendleton long-term experiments: Implications for biofuel production in Pacific Northwest. Agronomy Journal 103: 253-260.
- Payne, W.A., P.E. Rasmussen, C. Chen, R. Goller, and R.E. Ramig. 2000. Precipitation, temperature and tillage effects upon productivity of a winter wheat-dry pea rotation. Agronomy Journal 92: 933-937.

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