A novel perennial pasture and winter wheat conservation agriculture intercrop system for central USA

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Introduction

The USA's federally funded Conservation Reserve Program (CRP) has largely been successful in restoring many critical ecosystem functions to millions of acres through the conversion of vulnerable croplands to diverse perennial plant communities—primarily to perennial grass and forb plantings. CRP contracts, however, on as much as 6.5 million hectares (ha) are now expiring. Aside from leaving the land idle and economically unproductive as it was during the contract period, land owners typically have two options for managing post-contract CRP lands. Grazing or haying the perennial grass vegetation may be the best option for maintaining environmental benefits following contract expiration (Glover et al., 2010), but can offer low economic returns. Another option is to convert the land back to annual cropland for greater economic return. In the past, nearly 66 percent of post-contract CRP grasslands have been converted to annual cropland with roughly 30 percent remaining in perennial cover (USDA-ERS, 2005).

Studies of the effects of perennial grass on soil quality have illustrated a wide range of benefits (Karlen et al, 1999; Glover et al., 2010). Unfortunately, these benefits may be quickly lost once perennial grasslands are converted to annual cropping (Randall et al., 1997; Culman et al., 2010; DuPont et al., 2010), especially when tillage is used to kill the perennial cover (Culman et al., 2010). Direct conversion to no-till annual cropping (direct seeding) maintains some of the soil quality benefits of perennial grasslands but requires high chemical inputs and results in decreases in active soil carbon levels and changes in soil food web structure and function (DuPont et al., 2010).

The post-CRP contract dilemma of accepting lower economic returns from grazing or haying the perennial cover or accepting the loss of environmental benefits under annual cropping could be resolved by pasture-wheat intercropping (PWI). Pasture-wheat intercropping has been adopted by about 1000 growers in Australia as a means of conserving resources and increasing profits. Using the combination of perennials and annuals to integrate livestock and cropping operations on the same landscapes has improved profitability, increased management flexibility and maintained environmental benefits of continuous living plant cover.

To our knowledge, no studies of PWI systems used in the USA have been reported in the scientific literature. Here we report results of the impacts on soil health, productivity, crop quality, and profitability of PWI, grass hay production (HAY), and directed seeded annual crop (NT) systems.

Materials and Methods

This project included two research sites that had been in native vegetation, primarily warm-season grasses, for more than 20 years. Each site had three production treatments replicated three times: 1) warm-season meadow (dominated by big bluestem, *Andropogon gerardii*) for hay production (HAY); 2) no-till (NT) annual rotation of soybeans-wheat-sorghum; and 3) pasture-wheat intercropping (PWI) system. Each experimental plot was 4.5 m wide and 9.5 m long (43 m^2). The project consisted of four areas of study: **1.** soil characteristics; **2.** yield characteristics; **3.** economic inputs; and **4.** plant community composition. Yields of hay and grain were determined annually and enterprise budgets developed for each of the systems. Plant species composition and relative abundance was measured each year in early July.

Results and Discussion

Pasture wheat intercrop systems consistently achieved yields of 1.7 to 2.0 tons ha^{-1} of wheat with applications of 112 kg ha^{-1} of nitrogen fertilizer. These yield levels are economically competitive with no-till wheat monocultures, which require higher herbicide inputs and do not produce an additional hay crop following wheat harvest. Even on very poor sites, PWI systems produced 2.7 tons ha^{-1} grain yields with 224 kg ha^{-1} nitrogen fertilizer rates. Typical yield levels for NT systems were roughly 672 kg ha^{-1} greater.

Soil health, particularly in terms of increased levels of active soil organic carbon, improved in all managed systems compared to soil health in the hay production plots (unmanaged CRP plots). Hay yields were also higher in the PWI plots than in unmanaged CRP plots.

Plant diversity of PWI plots did increase but generally resulted in negative impacts on wheat grain yield. Increased presence of cool-season perennial grasses increased diversity but competed heavily with early season wheat growth, which consequently significantly reduced grain yields.

Presence of tan spot disease (as indicated by % of flag leaf affected) was greater in PWI systems (54%) compared to NT systems (19%). Greater disease presence likely resulted from the wetter, cooler canopy conditions due to greater shading and ground cover in PWI plots. The increased disease pressure indicates that identification of suitable varieties with strong rapid growth and disease resistance will be important to the long term success of PWI systems.

The greater availability of nitrogen in the PWI system, however, resulted in higher crude protein content (5.8%) compared to that measured (4.8%) in hay harvested from HP systems. The percent of neutral detergent fiber was not significantly higher in PWI systems despite the presence of the wheat straw.

Analysis of the economic performance of the pasture-wheat intercrop(PWI), no-till wheat monoculture (NT), and hay production (HP) systems, based on 2009 prices, indicate that using post-contract CRP lands simply for hay production would not cover production and land costs (Table 1). The NT and PWI systems provide net positive returns of $50 and $82 ha^{-1}, respectively. Despite lower wheat yields in the PWI system, the subsequent hay yield, which is greater than the hay produced by the HP system, increases overall profitability. Lower weed management costs in the PWI offers an additional advantage. The profitability of both systems is highly vulnerable to fluctuations in nitrogen fertilizer costs. The PWI system, because it is a more diversified enterprise, provides greater economic security in years when wheat yields are low.

Table 1. Summary of economic performance of study treatments.

	No-till	Wheat pasture intercrop	CRP grass
Wheat price ($ per bushel)	17	17	0
Hay price ($ per ton)	0	111	111
Yield/acre	0	0	0
Hay (tons)	0	3	2
Grain (bu.)	99	74	0
Revenue/acre	0	0	0
Hay	0	145	111
Grain	692	519	0
Total Revenue/acre	692	663	111
Costs ($) / acre	0	0	0
Seed	27	27	0
Pre-Harvest Machinery	0	0	0
No-Till Planting	34	34	0
Fertilizer Application	12	12	0
Herbicide Application	12	0	0
Fertilizer	0	0	0
Urea	89	89	0
Dap	226	226	0
Herbicide	0	0	0
Glyphosate	77	0	0
Harvest Machinery	0	0	0
Haying	0	29	29
Combine	53	53	0
Land Value (Cash Rent Equivalent)	111	111	111
Total costs/acre	642	581	140
Net return	50	82	(29)

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