Soil quality changes in eastern Washington with Conservation Reserve Program (CRP) take-out

V.L. Gewin, A.C. Kennedy, R. Veseth, and B.C. Miller

ABSTRACT: CRP lands in eastern Washington were eligible for dryland cropping production as of 1995. Conservation and conventional take-out practices were assessed at eight sites throughout eastern Washington to determine changes in soil quality parameters. The trials tested different tillage options: direct-seed/spring plant (DSP), conventional tillage/spring take-out (CSP), or conventional tillage/summer fallow (CSF). The eastern Washington sites range in annual precipitation from 23 to 36 cm (?? to ?? in) and in soil organic matter from 1.06 to 2.60%. Microbial biomass, readily-mineralized carbon (RMC), dehydrogenase activity, pH, organic matter content (OM), nitrate and ammonium concentrations, moisture, bulk density, and aggregate stability were monitored from 1995 to 1996. Results showed that RMC and pH were lower after one year in conventionally-tilled plots as compared to CRP grassland. The direct-seed samples were more like CRP grassland with respect to pH, dehydrogenase activity, and RMC than conventional tillage treatments.

Key words: Conservation Reserve Program, crested wheatgrass, direct-seed, erosion, no-till, soil microbiology, soil quality, tillage.

CRP, initiated by the 1985 Food Security Act, was designed to reduce erosion by taking highly erodible land (HEL) from production and replacing it with permanent vegetative cover (Lindstrom et al. 1994). This program was estimated to have saved seven million tons of soil per year from erosion (DeVore 1994). The first of the 10-year contracts from the original sign-up periods began expiring in 1995. Although CRP sign-up was extended with the 1995 Farm Bill, much of the initial CRP acreage may soon return to production because some of the land may not meet the requirements of the new program. Changes in soil quality are of critical importance in management decisions when returning these lands to production.

Washington state has more than one million acres of land in CRP (Miller 1995). These lands qualified for CRP based on their wind and water erosion potentials. Under the 1995 Farm Bill, their HEL designation will likely be based on a single index of either water or wind erosion (S. Liebing 1996, personal communication). On this basis, more than 80% of the enrolled CRP lands could be returned to production. If intensive tillage practices and management systems are used, the quality of these soils could diminish rapidly (Miller 1995; Peterson and Westfall 1995).

Wheat (*Triticum aestivum* L.)-fallow or wheat-barley (*Hordeum vulgare* L.)-fallow rotations are generally used in the 20- to 45-cm (8- to 17-in) rainfall region of eastern Washington (Miller 1995). Tillage intensity varies considerably in this region. During the transition to conservation practices in eastern Washington, farmers have experienced declining yields and incomes (Michalson and Papendick 1991). Direct-seed, or no-till, is not a widely used practice because of yield limitations attributed to weed, disease, and pest issues normally encountered in transition years (Papendick 1996). CRP may have provided the required time for soil structural and ecological changes necessary to limit these problems. The challenge of CRP take-out is to develop management systems that maintain improvements in soil carbon levels, fertility, aggregation, and structure developed during 10 years of undisturbed grass (Rosek et al. 1995; Lindstrom et al. 1994).

Soil quality is assessed by evaluating physical, chemical, and biological parameters (Parr et al. 1992; Doran 1980). Biological parameters, specifically microbiological, are responsible for many processes that facilitate changes in some physical and chemical characteristics of the soil. Conventional tillage practices decrease the organic matter content (Lindstrom et al. 1994; Frye and Blevins 1989; Anderson and Coleman 1985), and potentially mineralizable carbon and nitrogen (Wood and Edwards 1992). In low organic matter soils, such as many of those in CRP grass, increasing the percentage of surface organic matter content through reduced tillage can have positive effects on the soil physical condition (Angers et al. 1993; Arshad et al. 1990).

Changes in the physical and chemical parameters do not necessarily increase or decrease soil quality, but they can alter the microbial diversity and functioning of the system. Increased emphasis is being placed on the functional diversity of these systems to monitor changes in these ecosystems (Kennedy and Smith 1995; Zak et al. 1994). Microbial activity is involved in such processes as decomposition, nutrient cycling, and soil aggregation. Increased aggregation can lead to improved soil structure and decreased erosion potential (Lindstrom et al. 1994).

Monitoring soil quality changes during CRP take-out allows the opportunity to evaluate the effects of tillage and residue management on these lands. The goal of this project was to assess the initial soil quality changes in the first year of CRP grass take-out in eastern Washington. Objectives were to: 1) monitor changes in microbiological parameters, and 2) understand the relationships of these changes to physical and chemical characteristics in order to assess the impact of take-out on soil quality.

Materials and methods

This study was initiated in fall of 1994 to assess changes in soil quality during and after the take-out of CRP land. Regional take-out preferences and alternatives were assessed at eight different sites throughout eastern Washington. The trials emphasized either conventional tillage/summer fallow (CSF), conventional tillage/spring take-out (CSP), or direct-seed/spring plant (DSP); however, a variety of tillages were employed among the sites, only a few of which were preferred for all sites. There were three CSF trials (O'Neal, Richardson, and Roth), two CSP trials (Rustemeyer and Young), and three DSP trials (Galbreath, Jirava, and Viebrock). The Young site was unique as it had been in production for two years. All sites, with the exception of Rustemeyer, were in crested wheatgrass (*Agropyron cristatum* L.) for 8 to 9 yr (Table 1); the

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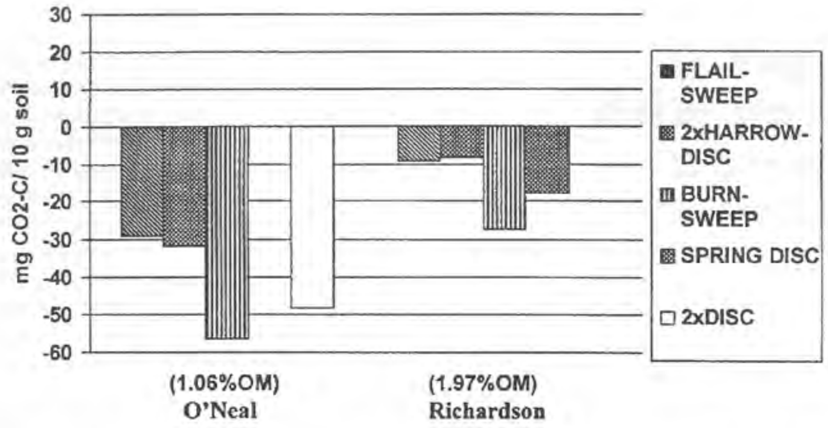

Figure 1. Percent change differences in conventional/summer fallow (CSF) treatments from Conservation Reserve Program (CRP) samples for readily mineralized carbon (RMC) - Spring 1995.

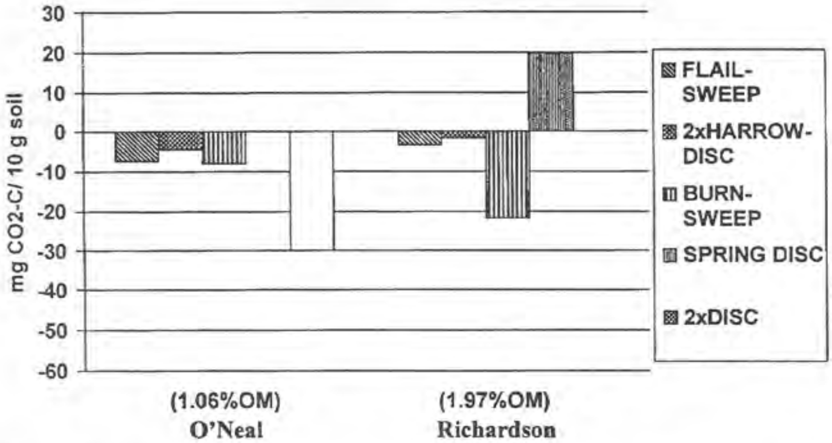

Figure 2. Percent change differences in readily mineralized carbon (RMC) between conventional/spring plant (CSP) treatments and Conservation Reserve Program (CRP) samples- Spring 1996.

Rustemeyer site was planted to tall wheatgrass (*Agropyron elongatum* L.). Soil quality parameters were examined after take-out to determine the effects of the practices within each trial. The CSF sites were sampled three times: spring 1995, fall 1995, and spring 1996 (Table 2). The CSF sites had both fall and spring tillage treatments during take-out. The CSP and DSP sites were sampled only in spring of 1996. Undisturbed CRP grass samples were taken in each cardinal direction at least 30 m (100 ft) from the grass take-out studies. Fall treatments were performed in early October of 1994, and spring take-out took place in late March of 1995 (Table 3).

Soil microbiological parameters. Soil surface samples of the top 15 cm (6 in) were collected and stored at 4° C. All microbiological analyses were completed within three weeks of sampling. Readily-mineralizable carbon (RMC) was measured by determining the amount of carbon dioxide produced in a 10-day incubation period from each 10-g dry weight sample (Zibliske 1994). Substrate-induced respiration (Anderson and Domsch 1990) was used to determine both biomass and basal respiration of the microorganisms from 10-g dry weight samples that were brought to 17% field moisture capacity. The samples were covered to minimize moisture loss and allow gas exchange, and incubated for 10 days at ambient temperature. One set of samples received 0.5 ml of a 3% glucose solution, while 0.5 ml of water was added to a duplicate set of vials of each soil sample, and both incubated for an additional 3 hr. CO_2 evolution was analyzed on a Hewlett Packard 5730A gas chromatograph. The remaining headspace from both experiments was then determined (Zibliske 1994). Dehydrogenase activity was determined colorimetrically after the 24-hr incubation of 5 g of dry weight soil in 1 ml of 3% triphenyl tetrazolium chloride (TTC) and 2 ml of 2% $CaCO_3$. The samples were extracted with MeOH, and the filtrate analyzed on a Bio Rad (Bio Rad, Hercules, Calif.) Model 2550 EIA Reader at 492 nm wavelength (Tabatabai 1994).

Soil chemical parameters. Samples taken in spring 1996 were assessed for organic carbon content using a modified

Table 1. Characteristics of field trials in CRP take-out in central/eastern Washington for 1995-1996

Type of Takeout	County	Soil Series	Cultivar	Annual Precipitation (cm)	% Organic Matter
CSF*	Franklin	Shano-Burke Silt Loam	Hatton Hard Red Wheat	24	1.08a**
CSF	Adams	Ritzville-Willis Silt Loam	Eltan Soft White Wheat	24	1.44b
DSP	Adams	Ritzville Silt Loam	Laura Hard Red Wheat	29	1.53bc
DSP	Adams	Ferrel-Stratford Very Fine Sandy Loam	Butte 86 Hard Red Wheat	24	1.66c
DSP	Douglas	Deercut-AARUP-White Eye Fine Sandy Loam	Butte 86 Hard Red Wheat	36	1.66c
CSF	Lincoln	Renslow Silt Loam	Eltan Soft White Wheat	24	1.95d
CSP	Starbuck	Walla Walla Silt Loam	Penawawa Soft White Wheat	36	1.97d
CSP	Lincoln	Baghdad Deep Silt Loam	Baronesse Barley	33	2.64e

*CSF: conventional summer fallow; CSP: conventional spring plant; DSP: direct-seed spring plant
** LSD values based on $p<0.05$

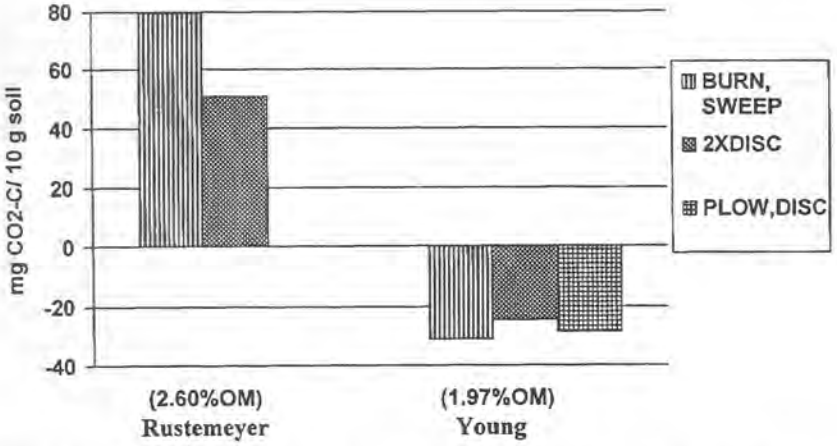

Figure 3. Percent change differences in for readily mineralized carbon (RMC) between direct-seed/spring plant (DSP) treatments and Conservation Reserve Program (CRP) samples - Spring 1996.

Walkley-Black method (Walkley and Black 1934), and analyzed colorimetrically on a Perkin Elmer UV/VIS Spectrophotometer (Perkin Elmer, Norwalk, Conn). Organic carbon values were converted to soil organic matter using a factor of 1.7 (Broadbent 1965). Soil pH was measured in a 1:1 ratio of soil and water, mixed thoroughly, and measured (Smith and Doran 1996) on an Orion Research microprocessor pH/millivolt meter 811 (Orion Research Inc., Boston, Mass.). Nitrate and ammonium concentrations were determined on two replications per site for 1996. The soil was extracted using a 1.0 M $MgSO_4$ solution, and analyzed using a NH_4^+ electrode (Pheonix Electrode Co., Maidstone, England) and a NO_3^- electrode (Orion Research Inc., Boston, Mass.) on an Orion Research microprocessor pH/millivolt meter 811 (Dahnke and Johnson 1990).

Soil physical analyses. Additional core samples (0 to 15 cm [0 to 6 in] depth, 6 cm [2.5 in] width) were taken in spring 1996 from all sites to determine bulk density and aggregate stability. Bulk density measurements were taken from two replications per site; while aggregate stability cores were analyzed for one replication per site. Whole soil cores were taken from each plot, and sieved into five size fractions (2 mm, 1 mm, 500 µm, 250 µm, and 150 µm). Wet aggregate stability measures were then taken on each size fraction of the sample by wetting up soil samples at 1 cm tension for 12 hr (Kemper and Rosenau 1986). Macroaggregate stability was defined as the percent of water-treated aggregates of each size fraction that survived filtration through a 53-µm sieve.

Data analyses

Data from the CSF sites were analyzed by ANOVA with a randomized complete block design with repeated measures on SAS (SAS Institute 1985). The repeated measures design uses a whole plot design with sampling date as the split plot factor of time to isolate variation due to seasonal or time changes. The ANOVA analyses tested the hypothesis that differences would exist between CRP grassland and the treated samples. Due to the repeated measures design, one set of LSD values was calculated from data for the same plots over all three sampling dates and used for each individual sampling date. The DSP and CSP sites were sampled only once in spring of 1996. A one-way ANOVA was used to determine differences among treatments. LSD values were calculated and are reported per site.

Analyses on representative samples. Organic matter content, bulk density, aggregate stability, and ammonium and nitrate concentrations were evaluated on representative samples from each site for only the spring 1996 sampling date. A 2-factor design (site versus treatment) was used over all of the sites. With the high number of treatments over all eight sites, treatments were grouped into 7 areas to better determine differences over sites (Table 3). ANOVA analyses were used to compare differences over site and treatments.

Results and discussion

Microbiological parameters. Readily-mineralized carbon (RMC) decreased at three of the five sites with conventional tillage practices (CSF and CSP trials) (Table 4). Trends in the data over these sites suggest that a relative decrease of up to 10 mg CO_2-C/10 g soil in RMC will result from conventional tillage. The most substantial decrease occurred right after the tillage treatments were established in 1995 (Figure 1). The spring-disc treatment at the Richardson (CSF) site (1.97% OM) increased after one year of take-out (Figure 2). No decreases were found in RMC at any of the sites involved in DSP trials. One site in each of the CSP and DSP trials increased RMC in the treatment samples as compared to the CRP (Figures 3 and 4).

The RMC represents an amount of carbon that is readily available to microbial communities. Fluctuations in the amount of RMC will result from soil disturbance and the amount and species of groundcover. It has been shown that crested wheatgrass may reduce soil quality compared to native grass species as a result of lower root exudates and unstable organic matter (Lesica and DeLuca 1996; Dormaar et al. 1995). The Rustemeyer site (CSP) had the highest overall percent OM (2.60%) (Table 1), in addition to the highest level of initial grass residue of all the sites. The increase in RMC at this site may be a result tall wheatgrass contributing more carbon to the system (Dormaar et al. 1995), thus more carbon was disturbed and released into the system. The increase in RMC at the DSP trial may be

Table 2.Timeline of events for the conventional tillage/summer fallow winter wheat (CSF), conventional tillage/spring plant (CSP), and direct-seed/spring plant (DSP) CRP trials.

Take-Out Type	Fall 1994	Spring 1995		Fall 1995		Spring 1996	
CSF	Fall tillage established	Spring tillage established	Spring samples taken	Winter wheat planted	Fall samples taken		Spring samples taken in standing winter wheat
CSP		Spring take-out at Young site				Second spring wheat crop on Young site	Spring samples taken in standing barley at Rustemeyer and standing barley at Young site
DSP						Spring takeout	Spring samples taken in standing spring wheat

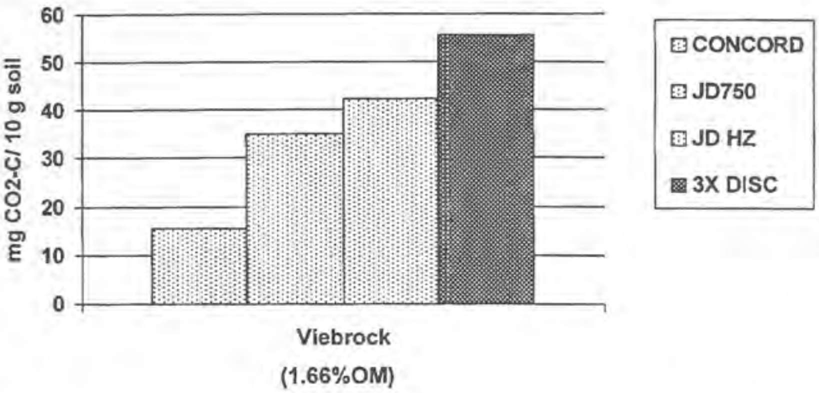

Figure 4. Percent change differences in for readily mineralized carbon (RMC) between conventional/spring plant (CSP) treatments and Conservation Reserve Program (CRP) samples - Spring 1996.

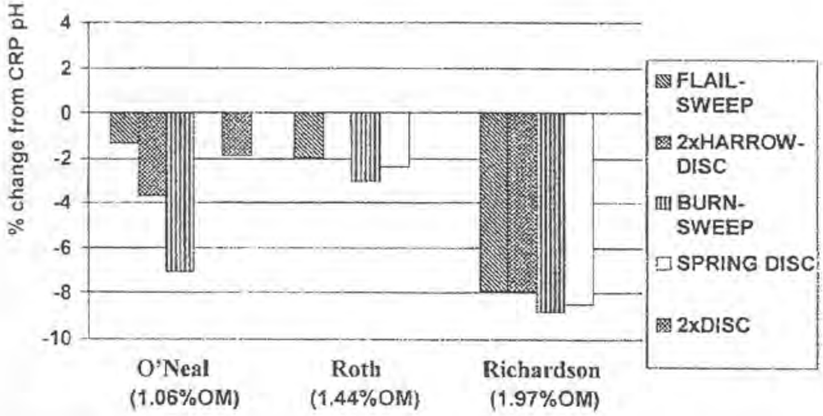

Figure 5. Percent change differences in pH between conventional/summer fallow (CSF) treatments and Conservation Reserve Program (CRP) samples - Spring 1995.

an anomaly since the other sites with direct-seed drills had no differences between treatments and CRP. No differences were found in biomass numbers in any of the types of take-out (Table 4,5). Initial changes in RMC such as these may indicate the beginnings of long-term decline in carbon levels (Biederbeck et al. 1994).

The conventional tillage treatments at the Young site showed decreased dehydrogenase activity as compared to CRP after two years of take-out (Table 4). The Young site was the only one in production for two years, which provides a unique look at the trends over time. Two years in production has reduced the amount of microbial activity present in these lands. The use of microbiological parameters as early indicators of soil quality shifts has long been identified (Kennedy and Papendick 1995; Visser and Parkinson 1992), and data from this study may reflect downward trends in microbial activity and carbon levels.

Chemical parameters. Differences in pH were seen between CRP samples and treatments at four of the five sites with conventional tillage treatments (CSF and CSP trials) (Table 6). All of the CSF trial sites decreased about 0.3 pH units as compared to CRP. The most substantial drop in pH occurred directly after treatments were established, most likely due to fertilizer applications (Figure 5). The Rustemeyer site (CSP) also dropped in pH about 0.2 pH units (Figure 3). No differences in pH were seen at the other CSP site (Young) after 2 years of take-out (Figure 6). Only one of the DSP trial sites decreased in pH after one year (Table 6). The Yielder direct-seed drill and spring disc treatments at the Galbreath site experienced a 0.2 pH units drop (Figure 7). The burn-Yielder treatment, however, was no different from CRP.

Organic matter and nitrate and ammonium concentrations were measured on representative samples from all sites in spring 1996. Differences in organic matter content were significant only between sites (Table 1). No treatment differences were found among the organic matter or ammonium concentrations. Treatment differences were found in nitrate concentrations for the Richardson and Young sites (data not shown). Lower nitrate concentrations were found in the CRP grass samples than in the other treatments at both sites.

Physical analyses. Bulk density and aggregate stability were assessed on representative samples from all sites in spring 1996. No treatment differences were found on bulk density measures, as expected, since physical and chemical characteristics are less responsive to disturbance than microbiological characteristics (data not shown). According to Doran (1996), soil quality evaluations may not be relevant on a weight basis, and suggested that comparisons be done on a volume basis. Since no differences in bulk density were found between sites, or between

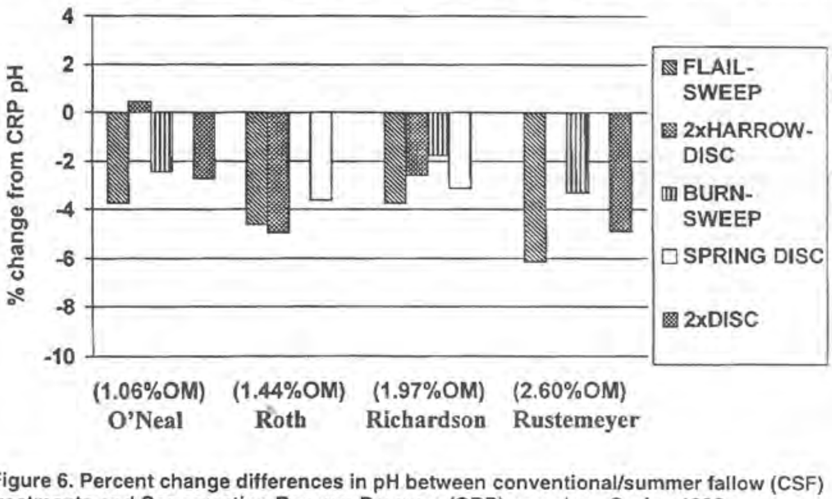

Figure 6. Percent change differences in pH between conventional/summer fallow (CSF) treatments and Conservation Reserve Program (CRP) samples - Spring 1996.

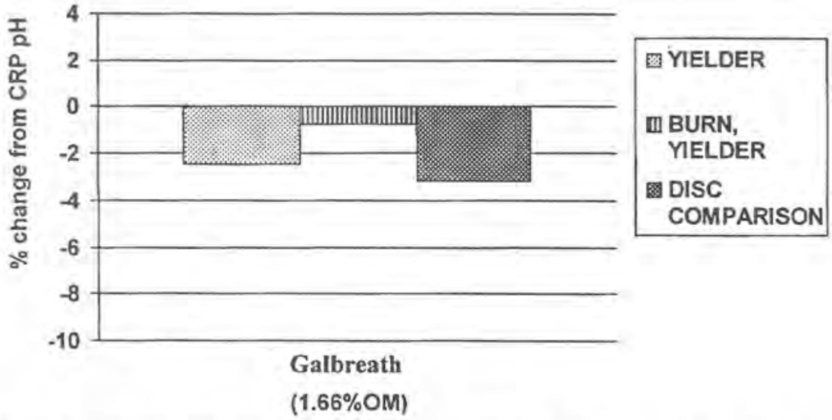

Figure 7. Percent change differences in pH between direct-seed/ spring plant (DSP) treatments and Conservation Reserve Program (CRP) samples - Spring 1996.

Table 3. Grower, trial, and treatments for the direct-seed/spring plant (DSP), conventional tillage/summer fallow (CSF) sites in east Washington for 1995-1996.

Grower	Take-Out Trial	Treatment	Spring Take-Out	Fall Take-Out
Galbreath	DSP	Direct-seed drill	Direct seed-yielder drill	
Galbreath	DSP	Conventional burn-sweep	Spring burn-direct seed yielder drill	
Galbreath	DSP	Minimum tillage	Disc, fertilize-coil pack-conventional drill	
Galbreath	DSP	CRP	CRP	
Jirava	DSP	Direct-seed drill	Concord hoe air drill	
Jirava	DSP	Direct-seed drill	JD 750 single disc drill	
Jirava	DSP	Direct-seed drill	JD HZ deep furrow hoe drill	
Jirava	DSP	Minimum tillage	Sweep, conventional JD double disc drill	
Jirava	DSP	CRP	CRP	
Viebrock	DSP	Direct-seed drill	Concord hoe air drill	
Viebrock	DSP	Direct-seed drill	JD 750 single disc drill	
Viebrock	DSP	Direct-seed drill	JD HZ deep furrow hoe drill	
Viebrock	DSP	Heavy tillage	3X disc, seed JD HZ	
Viebrock	DSP	CRP	CRP	
Rustmeyer	CSP	Minimum tillage	Flail - 2X sweep	
Rustmeyer	CSP	Heavy tillage	2X disc	
Rustmeyer	CSP	Conventional burn-sweep	Burn-2X sweep	
Rustmeyer	CSP	CRP	CRP	
Young	CSP	Heavy tillage	Plow-disc	
Young	CSP	Conventional burn-sweep	Burn-sweep	
Young	CSP	Heavy tillage	2X disc	
Young	CSP	Conventional spring disc	Sweep-disc	
Young	CSP	CRP	CRP	
Roth	CSF	Conventional fall disc	Disc	Cultivate
Roth	CSF	Heavy tillage	2X harrow-chisel	Skewtread-cultivator
Roth	CSF	Conventional spring disc		Disc-cultivator
Roth	CSF	Conventional spring disc		Sweep-disc
Roth	CSF	Minimum tillage	Flail with combine	
Roth	CSF	CRP	CRP	
O'Neal	CSF	Conventional burn-sweep		Burn-sweep
O'Neal	CSF	Conventional fall disc	Disc	Disc
O'Neal	CSF	Minimum tillage	2X harrow	Disc
O'Neal	CSF	Minimum tillage	Flail	Sweep
O'Neal	CSF	Heavy tillage		2X disc
O'Neal	CSF	CRP	CRP	
Richardson	CSF	Conventional burn-sweep		Disc
Richardson	CSF	Conventional spring disc		Disc
Richardson	CSF	Conventional spring disc		Flail-disc
Richardson	CSF	Conventional burn-sweep		Burn-sweep
Richardson	CSF	Conventional spring disc	2X harrow	Disc
Richardson	CSF	CRP	CRP	

treatments within sites, the data are presented on a gravimetric basis.

Differences in aggregate stability, determined as the percentage of stable aggregates (data not shown), were found at only one DSP site and two of the CSF sites. At the Galbreath (DSP) site, macroaggregate stability was higher for the burn/direct-seed and minimum tillage treatments than CRP in the 1-mm, 500-µm, and 250-µm fractions ($p < 0.05$). Greater aggregate stability was found at the Roth (CSF) site in the fall-disc treatment than the spring-disc or CRP grass treatments in the 500-µm fraction; fall-disc and spring-disc were greater than CRP grass in the 150-mm fraction ($p < 0.05$). At the Richardson (CSF) site, greater aggregate stability was seen in CRP grass than the burn-sweep and spring-disc treatments in the 150-mm fraction ($p < 0.05$). It is interesting to note that of the three sites that had differences, CRP samples had higher aggregate stability only in the site with the highest % OM (Richardson).

Correlations ($p < 0.05$) were found for five of the eight sites between stable aggregates and organic matter in the 150-µm size fraction. Correlations were found in only three of the eight sites in the 250-µm size fraction; one of the eight sites in the 500-µm size fraction; one of the eight sites in the 1-mm size fraction; and two of the eight sites in the 2-mm size fraction. The use of this correlation is most valid for assessing the importance of organic matter content to aggregate stability in the smallest size fractions.

Trial summaries. Overall, the direct-seed treatments were most similar to original CRP condition when compared with conventional tillage. No decreases were found in RMC with direct-seed. One of the three DSP sites also showed an increase in RMC from the CRP condition. Only one of three sites showed any decrease in pH. The initial effects were due to both the soil disturbance by tillage and fertilizer application. After one year, fewer differences were found between these treatments and CRP, suggesting that direct-seeding better maintained the soil quality conditions than the conventional practices.

The conventional tillage/summer fallow winter wheat (CSF) sites had a pattern of lower pH and RMC in the CSF treatments compared to CRP. The greatest changes took place at the CSF sites after the first spring of treatments. After only one year of CRP take-out in eastern Washington, decreases were found in soil quality parame-

Table 4. Biological analyses: conventional/summer fallow & conventional/spring take-out trials, central/eastern Washington 1995-1996.

Grower	Fall TRT	Spring TRT	Dehydrogenase (ug TPF/ g soil/ hr)			Biomass (C/100 g soil)			RMC* (mg CO2-C/ 10 g soil)		
			spr95	fall95	spr96	spr95	fall95	spr96	spr95	fall95	spr96
O'Neal	Flail	Sweep	3.54	1.97	2.53	26.6	34.5	66.7	**34.2b****	**26.3b**	**19.5a**
O'Neal	2X harrow	Sweep	2.94	1.90	2.74	23.9	31.5	52.8	**31.9b**	**21.4ab**	**20.0a**
O'Neal		Burn, sweep	2.70	1.78	2.77	27.1	26.0	45.6	**21.2a**	**15.8a**	**19.4a**
O'Neal	Disc	Disc	2.79	1.89	2.02	29.1	27.1	36.1	**29.5ab**	**21.4ab**	**14.6a**
O'Neal		2X Disc	2.70	2.16	2.61	27.9	32.6	32.2	**24.9ab**	**21.9ab**	**14.7a**
O'Neal	CRP	CRP	2.84	2.54	2.02	29.3	27.8	46.8	**48.4c**	**29.2b**	**21.1a**
p-value			NS	NS	NS	NS	NS	NS	**0.003**	**0.004**	**0.004**
$LSD_{0.05}$									**10.3**	**10.3**	**10.3**
Richardson	Flail	Disc	2.57	1.74	1.99	33.5	64.0	45.8	**41.1a**	**42.2b**	**26.1a**
Richardson	2X harrow	Disc	4.55	2.3	2.14	44.1	45.5	61.3	**41.4a**	**41.4b**	**26.5a**
Richardson		Disc	4.13	1.83	2.39	38.5	41.4	81.9	**37.2a**	**35.4ab**	**32.4a**
Richardson		Burn, sweep	3.44	2.07	2.63	41.7	40.1	64.4	**27.4a**	**21.5a**	**21.1a**
Richardson	Disc	Sweep	3.45	2.09	2.49	36.2	35.9	62.5	**33.2a**	**51.9b**	**28.2a**
Richardson	CRP	CRP	5.33	2.25	1.74	40.5	62.7	67.1	**45.2a**	**90.8c**	**26.9a**
p-value			NS	NS	NS	NS	NS	NS	**0.008**	**0.008**	**0.008**
$LSD_{0.05}$									**19.6**	**19.6**	**19.6**
Roth	Disc		4.14	1.8	3	57.9	46.2	63.6	54.2	25.8	27.6
Roth	Combine	Sweep	3.01	1.87	2.93	33.1	41.9	56.5	30.0	25.9	23.8
Roth		Disc	3.19	1.9	2.75	59.0	36.0	54.7	25.5	30.6	22.4
Roth		Sweep, Disc	4.42	1.88	3.12	64.7	40.5	49.1	38.3	34.4	26.1
Roth	2X harrow chisel		3.41	1.74	3.16	55.6	38.4	47.5	40.1	26.7	28.8
Roth	CRP	CRP	4.27	2.05	2.44	51.9	37.5	57.0	32.3	32.1	20.1
p-value			NS	NS	NS	NS	NS	NS	NS	NS	NS
$LSD_{0.05}$											
Rustemeyer***		Mow, 2X sweep			2.85			130.6			**34.9b**
Rustemeyer		Burn, 2X sweep			3.46			114.4			**41.1b**
Rustemeyer		2X Disc			2.66			71.4			**34.6b**
Rustemeyer		CRP			2.27			80.8			**22.2a**
p-value					NS			NS			**0.03**
$LSD_{0.05}$											**11.4**
Young***		Burn, sweep			**1.99a**			24.6			**16.4a**
Young		Sweep, disc			**2.14a**			36.1			**16.3a**
Young		2X disc			**1.85a**			21.0			**17.9a**
Young		Plow, disc			**1.75a**			28.2			**16.9a**
Young		CRP			**2.88b**			33.8			**23.7b**
p-value					**0.0213**			NS			**0.05**
$LSD_{0.05}$											**6.2**

*RMC=Readily Mineralized Carbon

**Values in bold indicate sites having treatments significantly different from CRP

***Spring take-out only at these sites; sampled only in Spring 1996

ters as a result of conventional tillage practices used during take-out.

The conventional tillage/spring plant (CSP) trials involved two sites that differed from the other sites in the study: Rustemeyer was the only site planted to a tall wheatgrass, and the Young site was the only one in production for two years. Decreased RMC and dehydrogenase activity were found at the conventional tillage treatments of the Young site. As a result of tillage, microbial activity stabilized at a lower level. The Rustemeyer site increased RMC, most likely due to the high OM content. Decreases in pH occurred at both sites as a result of conventional management, mainly due to fertilization.

Conclusions

The magnitude and degree of change in the soil biological, chemical, and physical parameters from the original Conservation Reserve Program (CRP) condition is critical in soil quality investigations. Although crested wheatgrass may not be suited to improve soil quality parameters, it is the dominant cover crop in CRP acreage. Decreased levels of readily mineralized carbon (RMC) and pH, after only one year of conventional tillage, indicate that these practices may not sustain soil quality, especially for lands considered highly erodible. The CRP has established ideal conditions for direct-seed management.

The response of a particular system depends on the inherent soil physical and chemical characteristics of the system. The findings in this study illustrated that sites will be unique in their response to take-out. No one factor stands alone to account for differences among take-out systems. For those dryland cropping areas of eastern Washington, direct-seed management is an effective practice to maintain the soil quality most similar to CRP grassland.

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Table 5. Physical, chemical, and biological analyses for direct-seed/spring take-out in central/eastern Washington for 1995-1996.

Grower	Treatment	% Moisture	pH	Dehydrogenase (ug TPF/ g soil/ hr)	Biomass (C/100 g soil)	RMC* (mg CO2-C/ 10 g soil)
Galbreath	Yielder	2.44	**6.66ab****	6.35	116.20	33.19
Galbreath	Burn, yieler	2.35	**6.81ab**	5.58	93.07	28.45
Galbreath	S-disc	2.67	**6.64b**	6.30	126.84	43.88
Galbreath	CRP	3.90	**6.86a**	6.26	134.41	43.30
p-value		NS	**0.05**	NS	NS	NS
$LSD_{0.05}$			**0.2071**			
Jirava	Concord	**2.38a**	6.27	4.09	61.20	40.78
Jirava	JD 750	**2.42a**	6.36	4.02	66.89	43.02
Jirava	JD HZ	**2.29a**	6.26	4.28	57.95	46.96
Jirava	Min. till	**2.55a**	6.18	4.50	68.99	48.89
Jirava	CRP	**3.21b**	6.46	3.91	53.04	58.24
p-value		**0.023**	NS	NS	NS	NS
$LSD_{0.05}$						
Viebrock	Concord	**3.06a**	7.15	5.89	130.86	**38.88a**
Viebrock	JD 750	**2.82a**	7.12	5.92	111.14	**45.43ab**
Viebrock	JD HZ	**3.00a**	6.79	5.63	106.02	**47.88b**
Viebrock	3X DISC	**3.03a**	7.02	5.49	69.45	**52.43b**
Viebrock	CRP	**3.72b**	7.15	4.99	60.07	**33.67a**
p-value		**0.0492**	NS	NS	NS	**0.0277**
LSD 0.05		**0.5883**				**13.511**

*RMC=Readily Mineralized Carbon

**Values in bold indicate sites having treatments significantly different from CRP

Table 6. Physical and chemical analyses for conventional/summer fallow and conventional/spring take-out sites in central/eastern Washington for 1995-1996.

Grower	Fall TRT	Spring TRT	% Moisture spr95	% Moisture fall95	% Moisture spr96	pH spr95	pH fall95	pH spr96
O'Neal	Flail	Sweep	6.47	9.18	11.68	**6.73b**	**6.14**	**6.39a**
O'Neal	2X harrow	Sweep	6.84	8.74	11.34	**6.57ab**	**5.79ab**	**6.67a**
O'Neal		Burn, sweep	6.25	9.07	11.69	**6.34a**	**5.92ab**	**6.48a**
O'Neal	Disc	Disc	6.29	8.04	11.50	**6.51ab**	**5.68a**	**6.43a**
O'Neal		2X disc	6.29	9,48	11.73	**6.69ab**	**5.80ab**	**6.46a**
O'Neal	CRP	CRP	6.74	4.79	13.85	**6.82b**	**6.54c**	**6.64a**
p-value			NS	NS	NS	**0.01**	**0.01**	**0.01**
$LSD_{0.05}$						**0.3858**	**0.3858**	**0.3858**
Richardson		Disc	**15.31c**	**10.24b**	**17.92a***	**6.24a**	**5.62a**	**5.98a**
Richardson	Flail	Disc	**15.06bc**	**10.68b**	**17.84a**	**6.28a**	**5.62a**	**5.94a**
Richardson		Burn, sweep	**14.61bc**	**10.02b**	**17.77a**	**6.22a**	**5.56a**	**6.06a**
Richardson	2X harrow	Disc	**14.9bc**	**10.38b**	**18.53ab**	**6.46ab**	**6.08b**	**6.01a**
Richardson	Disc	Sweep	**14.13b**	**9.71b**	**17.5a**	**6,21a**	**5.72ab**	**5.97a**
Richardson	CRP	CRP	**12.47a**	**7.77a**	**22.96b**	**6.82b**	**6.56c**	**6.17a**
p-value			**0.003**	**0.003**	**0.003**	**0.0013**	**0.0013**	**0.0013**
$LSD_{0.05}$			**1.126**	**1.126**	**1.126**	**0.422**	**0.422**	**0.422**
Roth	Combine	Sweep	**12.75bc**	**7.98b**	**15.85a**	**6.5ab**	**5.96b**	**6.16a**
Roth		Disc	**12.37bc**	**8.44b**	**16.76a**	**6.47ab**	**5.81ab**	**6.23a**
Roth	Disc		**12.25b**	**7.35b**	**16.42a**	**6.36a**	**5.69a**	**6.27ab**
Roth		Sweep, disc	**13.04bc**	**8.32b**	**16.24a**	**6.56ab**	**5.89ab**	**6.20a**
Roth	2X harrow Chisel		**13.48c**	**8.13b**	**16.37a**	**6.43ab**	**5.73a**	**6.14a**
Roth	CRP	CRP	**8.67a**	**5.21a**	**18.29b**	**6.63b**	**6.63c**	**6.46b**
p-value			**0.001**	**0.001**	**0.001**	**0.0001**	**0.0001**	**0.0001**
$LSD_{0.05}$			**1.209**	**1.209**	**1.209**	**0.2161**	**0.2161**	**0.2161**
Rustemeyer**		Mow, 2X Sweep			**4.26a**			**5.95a**
Rustemeyer		2X Disc			**4.03a**			**6.03a**
Rustemeyer		Burn, 2X sweep			**4.15a**			**6.13a**
Rustemeyer		None			**6.75b**			**6.34b**
p-value					**0.0244**			**0.0049**
$LS_{0.05}$					**1.84**			**0.1827**
Young**		Plow, disc			14.79			6.14
Young		Burn, sweep			13.30			6.29
Young		2X disc			16.08			6.11
Young		Sweep, Disc			14.30			6.08
Young		None			16.10			6.36
p-value					NS			NS
$LSD_{0.05}$								

*Values in bold indicate sites having treatments significantly different from CRP

**Spring take-out only at these sites; sampled only spring 1996

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