CROP RESIDUE AND FERTILIZER MANAGEMENT EFFECTS ON SOYBEAN, WHEAT, AND GRAIN SORGHUM IN EASTERN KANSAS

Keith A. Janssen and David A. Whitney

Associate Professor and Professor, Dept. of Agronomy, Kansas State University, Manhattan, KS 66506-5501

ABSTRACT

Removal of crop residue is being considered for many non-agricultural uses. The agronomic consequences of these practices are not fully known, especially for different levels of fertilizer management. An experiment was begun in eastern Kansas in 1980 to determine the effects of returning different levels of crop residue on soil properties and crop yields in a soybean-wheat-grain sorghum rotation, fertilized with different amounts of N-P-K fertilizer. Crop residue treatments included residue removed, normal residue incorporated, and 2X normal residue incorporated, each with zero, low, normal, and high levels of N-P-K fertilizer. Grain and residue yields varied with crops and years. Removal or doubling of crop residue did not decrease or increase grain or residue yield in 12 consecutive years of treatments, except for one year when residue yield was affected by hail damage. Crop residue removal reduced soil-exchangeable K; lowered soil organic matter ($P < 0.12$); and increased slightly soil bulk density. Doubling of the crop residue increased soil-exchangeable K, especially at high K fertilizer levels; slightly increased soil available P; and decreased slightly soil bulk density. Considering these effects and no differences in crop yields, intermittent or short-term removal of crop residues should not be that harmful if soil erosion and soil water relations are no problem and soil K is maintained. Use of long-term, continuous removal practices (longer than the 12 years in this study), is still questionable because slowly developing cumulative effects could influence yields long-term. More years of testing are needed to address long-term continuous removal practices.

INTRODUCTION

Crop residues are being used for livestock feed, bedding, fuel for drying grain, and even are being considered as feed-stock for ethanol production and manufacture of lumber products. The agronomic effects of not returning these crop residues to the soil are not fully known. The foremost concern is with soil erosion control, and whether crop residue removal will jeopardize conservation compliance. Other concerns include residue removal affects on soil water, including infiltration and conservation. Longer-term concerns are the depletion of plant nutrients, loss of soil organic matter, and changes in soil physical properties. The time-table and the seriousness of

these latter occurrences are not well documented, especially when using different levels of fertilizer management.

The purpose of this study was two-fold: (1) to determine the effects of returning different levels of crop residue on soil properties and crop yields in a soybean-wheat-grain sorghum rotation, fertilized with different amounts of N-P-K fertilizer, and (2) to determine the quantities of crop residue produced by these crops under eastern Kansas conditions.

MATERIALS AND METHODS

The study was conducted at the East Central Kansas Experiment Field near Ottawa, KS on a nearly level, non-erosive, (0-1% slope) Woodson silt loam soil (fine montmorillonitic, thermic Abruptic Argiaquoll). Residue treatments were begun in the fall of 1980 following a uniform planting of grain sorghum; and were continued for 12 consecutive years (through 1992) using a soybean, wheat, grain sorghum cropping sequence. Only one crop was grown each year. Residue treatments included (1) residue removed annually after grain harvest (aboveground portion by mowing and raking), (2) normal residue incorporated, and (3) twice (2X) normal residue incorporated (accomplished by spreading evenly the residue from the residue removal treatments). Superimposed over the residue treatments were fertilizer treatments; zero, low, normal and high levels of N-P-K fertilizer as shown in Table 1 for the individual crops. The experiment design was a split-plot with residue treatments as whole plots and the fertilizer treatments as sub plots. There were four replications of each treatment. Grain yields and residue yields were measured each year. Soil samples (0-6 inch depth) were collected after the 1991 crop (11th year) for soil chemical analysis. Soil bulk density measurements were also taken in the 0-4 inch depth for the zero and high fertilizer treatments for the three residue treatments. A conventional tillage system with fall disk, spring disk, and a field cultivation before planting was used for seedbed preparation and residue incorporation.

RESULTS AND DISCUSSION

Yields

Grain and residue yields for the crops are summarized in Tables 2 and 3, respectively. There was no interaction ($p < 0.05$) between the residue and fertilizer treatments in any year for grain or residue yield. Consequently, only main effects of treatments are presented. Grain yields and residue yields varied with crop and year. Soybean grain yields ranged from 14 to 53 bu/a with residue yields ranging from 0.34 to 0.81 tons/a; wheat grain yields ranged from 29 to 50 bu/a, with residue yields ranging from 0.99 to 1.47 tons/a; and grain sorghum grain yields ranged from 54 to 129 bu/a, with residue yields ranging

from 1.11 to 2.66 tons/a. These grain and residue yield ranges verify that crop residue yields, like those of grain, will vary substantially with growing season. Although direct residue production comparisons cannot be made because all crops were not grown in the same year for the years grown, grain sorghum produced the highest overall amount of residue (1.69 ton/a average), wheat was intermediate (1.20 ton/a average), and soybean produced the least residue (0.57 ton/a average).

The residue treatments produced no statistically significant ($p < 0.05$) differences in grain or residue yield for any crop in any year except for soybean residue yield in 1987. That year, residue yield was highest for the residue removal treatment and lowest for the 2X normal residue treatment. This could be because of hail damage that year. Grain and residue yields when totaled for the entire 12 year period differed by less than 1.5 percent for all residue treatments.

The fertilizer treatments increased grain and residue yields almost every year. Wheat grain yields were increased in 4 out of 4 years; grain sorghum, in 3 out of 4 years; and soybean, in 2 out of 4 years. Fertilizer applications also increased residue yields. Wheat residue yields were increased in 4 out of 4 years; grain sorghum, in 2 out of 4 years; and soybean, in 2 out of 4 years. Generally, highest grain and residue yields were produced with the normal and high fertilizer treatments and lowest with the zero and low fertilizer treatments. These data show that well fertilized crops will benefit not only in grain yield, but also by increased residue production.

Soil Properties

Soil test results after 11 years of residue-fertilizer treatments are shown in Table 4. Statistical analysis shows significant differences ($p < 0.05$) in available P (Bray P-1 extractable), exchangeable K, and bulk density for residue treatments; plus a statistically significant interaction between the residue and fertilizer treatments for exchangeable K. Exchangeable K was affected most by the residue treatments. Exchangeable K decreased with crop residue removal in all fertilizer treatments (Figure 1). Doubling crop residue compared to removal or normal residue treatments increased exchangeable K especially at the higher K fertilizer levels (significant residue x fertilizer interaction). This was because of the high K in the residue, plus the fertilizer K, greatly exceeding crop K needs.

Soil organic matter (Figure 2) declined with crop residue removal compared to normal and 2X normal residue ($P < 0.12$). Doubling of crop residue in combination with high fertilizer produced the highest soil organic matter levels. Soil organic matter with normal residue incorporated tended to decrease with zero fertilizer, compared to higher fertilizer levels. Soil

bulk density increased slightly with removal of crop residue and decreased slightly with doubling of crop residue.

Fertilizer application produced the expected changes in soil properties, except for soil bulk density which increased slightly with fertilizer application. Soil pH decreased with fertilizer application. Available P, exchangeable K, and organic matter increased with fertilizer application. Soil NO_3-N and NH_4-N were not affected by the residue or the fertilizer treatments.

The results of this study suggest that in situations where soil erosion and soil water relations are not of concern, short-term or intermittent removal of crop residues should not be harmful. Removal of crop residue will likely lower soil organic matter and increase soil bulk density slightly in relation to normal residue incorporation, but the changes should be small and not affect crop yield. Maintaining an adequate K fertility program, however, will be essential. Effects of long-term, continuous residue removal, (longer than the 12 years in this study), are still unknown. These practices remain questionable because long-term removal could cause further declines in soil organic matter and cause soil physical problems. Whether this will occur, and at what point, can only be determined by longer-term testing.

Table 1. N-P-K fertilizer treatments used.

	Crop		
	Soybean	Wheat	Grain sorghum
Fertilizer treatments:	$N-P_2O_5-K_2O$	$N-P_2O_5-K_2O$	$N-P_2O_5-K_2O$
	---------- Lbs/acre ----------		
Zero	0-0-0	0-0-0	0-0-0
Low	0-0-0	25-15-25	50-15-25
Normal	0-0-0	50-30-50	100-30-50
High	0-0-0	75-45-75	150-45-75

Table 2. Crop residue and fertilizer treatment effects on grain yields of successive soybean, wheat, and grain sorghum, 1981-1992.

Treatment	Soy '81	Wht '82	G.S. '83	Soy '84	Wht '85	G.S. '86	Soy '87	Wht '88	G.S. '89	Soy '90	Wht '91	G.S. '92	12-yr total
							bu/acre						
Residue Means													
Removed	52	29	52	13	51	58	23	47	92	29	34	128	608
Normal	53	30	54	14	49	56	22	49	93	29	37	127	613
2X Normal	54	28	55	14	50	57	22	49	89	27	39	130	614
L.S.D. 0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Fertilizer Means													
Zero	53	23	51	13	38	47	22	39	84	27	26	120	543
Low	53	29	54	12	47	56	22	48	94	28	35	123	601
Medium	53	30	54	13	55	62	22	51	92	28	41	135	636
High	53	34	55	16	60	63	23	56	96	30	44	136	666
L.S.D. 0.05	NS	4	NS	2	3	4	NS	3	5	1	2	7	
Residue x Fert. Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 3. Crop residue and fertilizer treatment effects on residue yields of successive soybean, wheat, and grain sorghum, 1981-1992.

Treatment	Soy '81	Wht '82	G.S. '83	Soy '84	Wht '85	G.S. '86	Soy '87	Wht '88	G.S. '89	Soy '90	Wht '91	G.S. '92	12-yr total
							ton/acre						
Residue Means													
Removed	0.55	1.14	1.12	0.35	1.30	1.13	0.86	1.43	2.59	0.54	0.92	1.80	13.73
Normal	0.62	1.12	1.11	0.34	1.16	1.14	0.81	1.49	2.70	0.54	1.00	1.85	13.88
2X Normal	0.64	1.19	1.11	0.33	1.14	1.16	0.74	1.48	2.68	0.47	1.04	1.92	13.90
L.S.D. 0.05	NS	NS	NS	NS	NS	NS	0.06	NS	NS	NS	NS	NS	
Fertilizer Means													
Zero	0.60	1.04	1.04	0.33	0.87	1.11	0.75	0.89	2.34	0.50	0.65	1.83	11.95
Low	0.60	1.08	1.18	0.29	1.04	1.17	0.80	1.36	2.77	0.50	0.93	1.74	13.46
Medium	0.60	1.19	1.13	0.33	1.51	1.11	0.83	1.65	2.64	0.52	1.10	1.95	14.56
High	0.60	1.30	1.11	0.41	1.39	1.18	0.85	1.98	2.87	0.55	1.27	1.90	15.41
L.S.D. 0.05	NS	0.11	NS	0.08	0.27	NS	0.06	0.12	0.17	0.04	0.11	0.17	
Residue x Fert. Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 4. Soil test values after eleven years residue and fertilizer treatments, Woodson silt loam soil.

Treatment	Soil pH	Soil available P	Soil exchangeable K	Soil organic matter	Soil NO_3-N	Soil NH_4-N	Soil bulk density
		lbs/a	lbs/a	%	ppm	ppm	gms/cc
Residue Means:							
Removed	6.4	46	202	2.8	10	3	1.16
Normal	6.3	45	246	3.1	11	3	1.13
2X Normal	6.3	48	298	3.2	10	3	1.10
L.S.D. 0.05	NS	2	32	NS	NS	NS	0.02
Fertilizer Means:							
Zero	6.5	35	198	2.9	11	3	1.12
Low	6.4	41	228	3.0	11	3	-
Medium	6.3	52	271	3.1	9	3	-
High	6.2	58	299	3.1	10	3	1.14
L.S.D. 0.05	0.1	5	29	0.1	NS	NS	0.01
Residue x Fert. Interaction	NS	NS	*	NS	NS	NS	NS

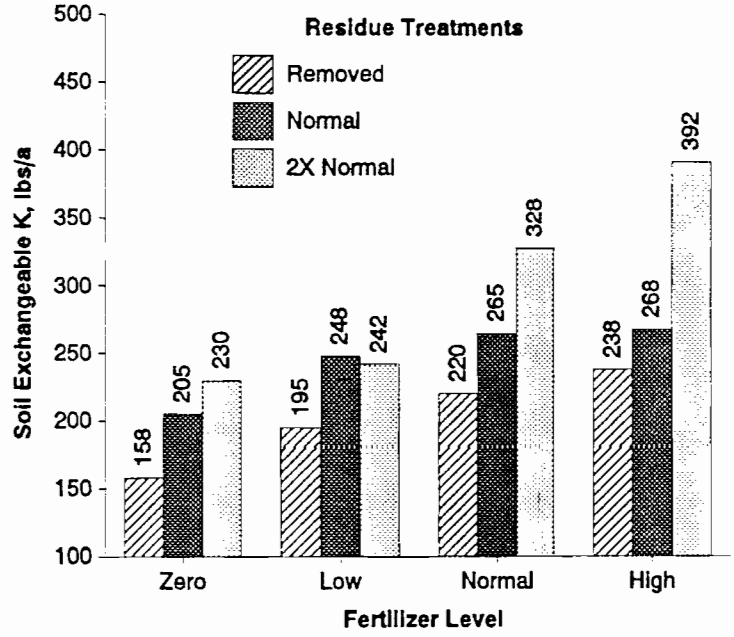

Figure 1. Soil Exchangeable K After 11 Years Residue and Fertilizer Treatments.

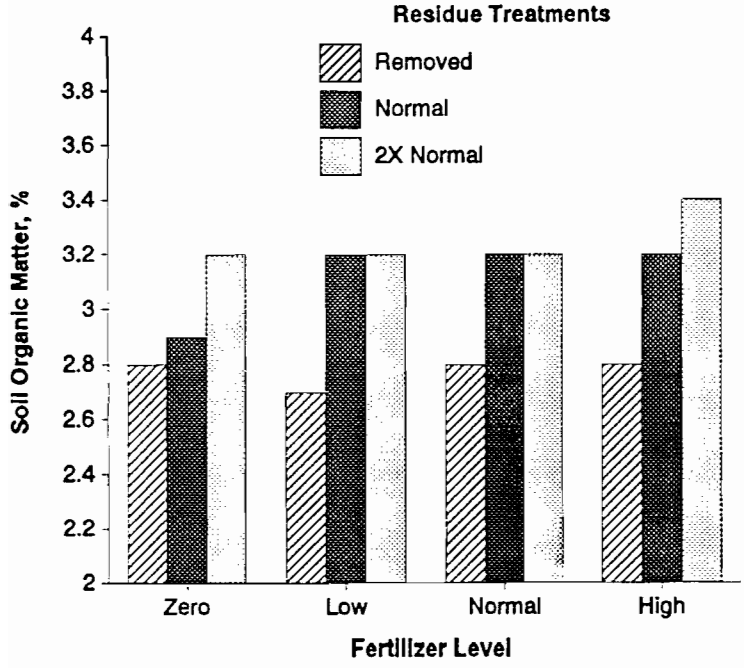

Figure 2. Soil Organic Matter After 11 Years Residue and Fertilizer Treatments.

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Research and Education Center
P.O. Box 469
Princeton, KY 42445