September 2002

Residual Effects of Compost and Fertilizer Applications on Nutrients in Runoff

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RESIDUAL EFFECTS OF COMPOST AND FERTILIZER APPLICATIONS ON NUTRIENTS IN RUNOFF

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ABSTRACT. *The application of compost or fertilizer at rates that exceed crop nutrient requirements can result in phosphorus (P) and nitrogen (N) accumulation in soil. This study was conducted to determine the influence of soil P and N contents on the concentrations and total amounts of P and N transported in runoff. Composted beef cattle feedlot manure or inorganic fertilizer were added from 1992 to 1995 to a Sharpsburg silty clay loam soil at rates sufficient to meet P or N requirements for corn and incorporated following application. After four years of corn production following the last compost application, P concentration, EC, and pH of the surface soils on the N–based compost treatments were significantly greater than the check plots. Simulated rainfall was applied to the experimental site in 2000. Concentrations and total amounts of P and N in runoff were similar on the compost and inorganic fertilizer plots. The application of corn residue at a rate of 6 Mg ha^{-1} did not significantly affect the nutrient concentration of runoff or total nutrient transport when compared to a no–residue condition for a study site with a slope varying from 0.15% to 2.70%. On an adjoining field, compost or inorganic fertilizer were applied at rates in excess of crop P and N requirements to increase soil test P levels. For Bray and Kurtz No. 1 soil test P levels ranging from 42 to 267 mg kg^{-1} and water–soluble soil test P values varying from 5 to 61 mg kg^{-1}, the dissolved P (DP) concentration of runoff did not correlate well with soil test P. Thus, factors other than soil test P appear to influence P loss in runoff for the bare soil used in this investigation.*

Keywords. *Eutrophication, Manure management, Nitrogen movement, Nutrient losses, Runoff, Phosphorus, Water quality.*

Manure can serve as a source of important plant nutrients including P and N. The land application of manure can produce crops similar to those obtained using inorganic fertilizer (Eghball and Power, 1999). Soil organic matter contained in manure can significantly increase soil aggregation, infiltration, microbial activity, structure and water holding capacity, and can reduce soil compaction and erosion (Gilley and Risse, 2000; Haynes and Naidu, 1998). Chemical properties improved by manure application include cation exchange capacity and soil buffering potential (Tisdale et al., 1993).

The use of manure as a nutrient source and soil amendment can create water quality problems. Runoff from land application areas may contain soluble contaminants or insoluble pollutants carried on soil particles. Concentrations of dissolved P (DP), bioavailable P, and NH_4–N in runoff were found to be significantly greater when the soil was not disked (Eghball and Gilley, 1999). When manure or compost is applied under no–till conditions without incorporation, the excessive P concentration of runoff can cause eutrophication. Reduced dissolved oxygen levels and high concentrations of ammonium can also seriously affect aquatic organisms including fish.

The concentrations of P in runoff from land application areas have been shown to increase as the P contents of soil become greater (Pote et al., 1996). The N–to–P ratio in manure is lower than that utilized by crops. As a result, excessive P levels can accumulate on sites where manure has been added to meet crop N requirements. The method, timing, and amount of manure that is applied can be modified to reduce the quantity of P that accumulates in soil. Although recent compost application can result in significant loss of P and N in runoff, the residual effects of compost application on nutrient transport are not well documented. The objectives of this study were to:

- Determine the effects on soil properties of annual or biennial application of compost based on N and P requirements for corn, after four years of corn production following the last compost application.
- Measure nutrient transport in runoff as affected by the application of composted beef cattle manure or inorganic fertilizer four years earlier to meet either P or N requirements of corn.
- Characterize the effects of corn residue on nutrient transport from plots having a mean slope of 1.02% on which composted beef cattle manure or inorganic fertilizer were applied.
- Develop regression equations relating the DP concentration of runoff to soil test P from plots on which compost or fertilizer were applied.

Article was submitted for review in April 2002; approved for publication by the Soil & Water Division of ASAE in September 2002. This article is a contribution from the USDA–Agricultural Research Service in cooperation with the Agricultural Research Division, University of Nebraska, Lincoln, and is published as Journal Series No. 13691.

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Materials and Methods

The experimental site was established in 1992 on a Sharpsburg silty clay loam soil (fine, smectitic, mesic Typic Argiudoll) at the University of Nebraska Agricultural Research Center near Mead, Nebraska. The slope at the site varied from 0.15% to 2.70% and had a mean value of 1.02%. The six replicated experimental treatments, established in a randomized complete block design, included annual or biennial compost application based on N or P removal by corn (151 kg N ha^{-1} and 25.8 kg P ha^{-1} for an expected yield of 9.4 Mg ha^{-1}; Gilbertson et al., 1979) and fertilized and unfertilized checks. Additional details concerning the experimental location are provided by Eghball (2002).

Fertilizer was applied at the site in the spring of 1993, 1994, 1995, and 1996. The inorganic fertilizer plots received N as NH_4NO_3 (34–0–0, N–P–K) and P as superphosphate (0–20–0, N–P–K) in 1993 and diammonium phosphate (18–20–0, N–P–K) in 1994, 1995, and 1996. As necessary, the P–based treatments (annual or biennial application) received additional N fertilizer as NH_4NO_3 in the spring for a total available N application of 151 kg ha^{-1}. Following the spring of 1996, only the inorganic fertilizer treatment received a single additional fertilizer application in 1999 at the rates used previously.

Beef cattle manure was collected from the feedlot pens in late spring each year and composted for about 4 months using active turning. The composted manure was applied by hand in the autumn of 1992, 1993, 1994, and 1995. Compost was added to provide 151 kg N ha^{-1} for N–based and 25.8 kg P ha^{-1} for P–based application rates. Residual P and N values were considered when compost was added. Compost was last applied to the 4.6–m wide by 12.2–m long plots in the autumn of 1995.

Total P and N in compost were determined from air–dried samples using established procedures (Johnson and Ulrich, 1959; Knudsen et al., 1981; Schepers et al., 1989). Within two days after application, compost was incorporated into the top 10–cm of soil by disking. Corn was grown at the site from 1993 to 1999 using a seeding rate of 47,000 seeds ha^{-1} and a row spacing of 0.76 m (Eghball and Power, 1999). Weed control was achieved by band application of herbicide in the corn rows at planting and by cultivation. Herbicide was applied to the study area during the summer of 2000 to prevent weed growth.

Three soil samples (1.9–cm diameter) were collected to a depth of 15 cm from each plot before the rainfall simulation tests. The soil samples were divided and composited into 0 to 5 cm and 5 to 15 cm increments. The soil samples were air dried and analyzed for water–soluble P, Bray and Kurtz No. 1 P, NO_3–N, NH_4–N, EC, and pH. Water–soluble P and Bray and Kurtz No. 1 P were determined using procedures developed by Murphy and Riley (1962) and Bray and Kurtz (1945), respectively. The concentration of P in a water extract of the soil is provided by the water–soluble P test. As an index of P availability, the Bray and Kurtz No. 1 procedure provides a relative determination of the P concentration level in the soil solution that limits the growth of plants. Soil NO_3–N and NH_4–N concentrations were measured with a flow injection analyzer using spectrophotometry (Lachat system from Zellweger Analytics, Milwaukee, Wisc.).

One of the goals of this study was to develop regression equations relating the DP concentration of runoff to soil test P. This goal could be best achieved by using plots having a wide range of soil test P values. Thus, varying rates of compost or diammonium phosphate (18–20–0, N–P–K) were applied to selected additional plots in November 1999. The 3 m^2 plots were established on an area adjoining the study site described previously. Corn had been grown at this location for several years, with inorganic fertilizer serving as the nutrient source. The area was disked following compost and fertilizer application. During the summer of 2000, herbicide was applied to the study site to prevent weed growth during the rainfall simulation period.

A rainfall simulator was fabricated, using a nozzle described by Shelton et al. (1985), to apply rainfall at a design intensity of approximately 70 mm hr^{-1} during four simulation runs. Each of the simulation runs occurred on the same day and lasted for 30 minutes. The water used in the simulator was taken from a domestic supply having a NO_3–N and PO_4–P content of 6 and 0.4 mg L^{-1}, respectively. Samples for characterizing the nutrient content of the water supply were collected each day. The nutrient content of the domestic water supply was subtracted from runoff nutrient values to obtain the nutrient concentrations reported in this study.

Sheet metal strips were used to establish plots that were 0.75–m wide by 2.0–m long, as described by Pote et al. (1996). A flow collection trough diverted runoff into a 64–L washtub. The washtub was located outside of the area that received rainfall. Following installation of the plot borders and collection trough, the plot area was raked to remove crop residue and smooth the soil surface. To reduce runoff variability due to antecedent soil water conditions, burlap material was placed on the soil surface and the plots were wet until ponding occurred prior to the initial rainfall simulation test.

Corn residue remaining from the previous harvest was collected from a site near the study area in May 2000. The residue material was first placed in an oven maintained at 60° C for 48 hours. The material was then weighed and stored in plastic bags for later use. For the fourth rainfall simulation event, corn residue was placed on one of the paired plots at a rate of 6 Mg ha^{-1}. This residue rate was selected to provide a surface cover of approximately 50% (Gilley et al., 1986). No residue was on the soil surface for the first three runs. The same rainfall simulation and runoff collection procedures used previously were employed during the fourth rainfall simulation event.

After each rainfall simulation run, the washtub was weighed to determine the total volume of runoff. Two samples for sediment analysis and two samples for nutrient analysis were obtained from the washtub. The collection bottles used to measure soil loss rates were weighed, dried, and re–weighed to identify the mass of sediment and water in the bottles. The samples collected for nutrient analyses were centrifuged, filtered, and analyzed using procedures outlined previously. Non–centrifuged samples were analyzed for total P (Johnson and Ulrick, 1959), total N (Tate, 1994), pH, and EC.

Duncan's Multiple Range Test (Littell et al., 1996) was used to separate means. Significant differences between experimental treatments were identified at the 5% probability level. Analysis of variance was also employed to analyze the runoff data using the PROC MIXED function of SAS (Littell et al., 1996). Tests to identify significant differences between experimental variables and treatments at the 5%

probability level were conducted using LSD procedures. Linear regression analysis was used to determine the correlation between DP and soil test P.

Results and Discussion

Residual Effects of Compost and Fertilizer Application on Soil Properties

After four years of corn production following the last compost addition, water–soluble and Bray and Kurtz No. 1 soil test P values at both the 0 to 5 cm and 5 to 15 cm soil depths were significantly greater on the N–based compost treatments than on the fertilizer and check plots (table 1). The residual amounts of water–soluble and Bray and Kurtz No. 1 soil test P remaining at the 0 to 5 cm depth on the plots receiving biennial N requirements were significantly greater than the quantities found on the other experimental treatments. Similar amounts of water–soluble and Bray and Kurtz No. 1 soil test P were found on the fertilizer and check plots at both depth increments.

Manure can provide N to crops for several years. A decay series for estimating N availability following application of a specific type of manure was proposed by Pratt et al. (1973). For beef cattle manure containing 1.5% N, approximately 35%, 15%, 10%, and 5% of the remaining N was available in the first, second, third, and fourth year after application, respectively. In this study, NO_3–N and NH_4–N concentrations in the compost and check plots, in general, were similar at both the 0 to 5 cm and 5 to 15 cm soil depths. Thus, after four years of corn production following the last compost application, there was little residual N at the study site (table 1).

EC and pH values at both the 0 to 5 cm and 5 to 15 cm soil depths on the N–based compost treatments were significantly greater than on the check plots (table 1). The $CaCO_3$ that was added to the beef cattle diet and was contained in the compost influenced soil EC and pH values. From measurements of surface soil (0 to 15 cm) collected at the study location from 1992 to 1996, Eghball (2002) also found that the N–based compost treatments had significantly greater pH values than the check plots.

Phosphorus and Nitrogen in Runoff

Concentrations and total amounts of P and N constituents, and EC and pH values, in general, were similar during the three rainfall simulation runs (tables 2 and 3). In general,

Table 1. Phosphorus and nitrogen concentrations and EC and pH of the treatments before the rainfall simulation runs.

	0 to 5 cm Soil						5 to 15 cm Soil					
Treatment[a]	WSP[b] (mg kg^{-1})	BKP[c] (mg kg^{-1})	NO_3–N (mg kg^{-1})	NH_4–N (mg kg^{-1})	EC[d] (d S m^{-1})	pH	WSP (mg kg^{-1})	BKP (mg kg^{-1})	NO_3–N (mg kg^{-1})	NH_4–N (mg kg^{-1})	EC (d S m^{-1})	pH
NA	23.1 b[e]	116.9 b	23.0 a	3.4 ab	0.57 a	6.6 a	15.3 ab	84.6 a	15.2 a	2.6 a	0.49 a	6.6 a
NB	32.5 a	162.7 a	14.5 ab	4.0 a	0.54 ab	6.6 a	20.6 a	102.4 a	10.9 abc	2.5 a	0.44 ab	6.5 a
PA	20.6 b	107.1 b	15.1 ab	2.3 b	0.52 ab	6.3 b	12.6 abc	95.9 a	10.4 abc	1.8 a	0.40 b	6.3 b
PB	14.8 bc	78.2 bc	24.2 a	2.7 b	0.50 ab	6.1 c	7.4 bc	44.3 b	13.7 ab	1.9 a	0.37 bc	6.1 c
FR	10.9 c	49.1 c	9.9 ab	2.6 b	0.35 bc	5.5 d	3.4 c	41.9 b	8.7 bc	2.1 a	0.31 c	5.8 d
CK	7.0 c	52.0 c	5.4 b	3.2 ab	0.32 c	6.3 b	3.1 c	36.6 b	7.2 c	2.4 a	0.30 c	6.3 b

[a] Compost applied to meet annual corn nitrogen requirements (NA), biennial nitrogen requirements (NB), annual phosphorus requirements (PA), biennial phosphorus requirements (PB), annual fertilizer application (FR), and check (CK).
[b] WSP = water–soluble P.
[c] BKP = Bray and Kurtz No. 1.
[d] EC = electrical conductivity; EC and pH were determined in 1:1 soil/water ratio.
[e] Values with different letters are significantly different at the 0.05 probability level based on Duncan's Multiple Range Test.

Table 2. Effects of run and residual effects of compost and fertilizer applications on concentrations of dissolved P (DP), bioavailable P (BAP), total P, nitrate–N, ammonium–N, total N, electrical conductivity (EC), and pH of runoff in 2000, and analysis of variance.

Variables[a]	DP (mg L^{-1})	BAP (mg L^{-1})	Total P (mg L^{-1})	NO_3–N (mg L^{-1})	NH_4–N (mg L^{-1})	Total N (mg L^{-1})	EC (d S m^{-1})	pH
Run								
One	0.33	0.51	1.61	0.38	0.09	25.13	0.62	7.74
Two	0.33	0.50	1.52	0.28	0.07	19.71	0.62	7.82
Three	0.35	0.55	1.69	0.31	0.06	20.85	0.62	7.82
$LSD_{0.05}$	NS	NS	NS	0.08	0.02	NS	NS	0.05
Treatment								
NA	0.40	0.47	1.36	0.33	0.04	16.00	0.63	7.94
NB	0.40	0.70	1.82	0.19	0.17	26.38	0.63	7.81
PA	0.37	0.58	2.25	0.46	0.08	26.58	0.64	7.70
PB	0.32	0.51	1.50	0.10	0.03	30.71	0.62	7.71
FR	0.27	0.43	1.48	0.42	0.07	13.21	0.62	7.79
CK	0.25	0.43	1.25	0.40	0.05	18.50	0.61	7.79
$LSD_{0.05}$	NS	NS	0.84	NS	0.10	NS	0.02	0.16
Analysis of variance (PR > F)								
Run	0.15	0.22	0.46	0.04	0.01	0.15	0.86	0.01
Treatment	0.42	0.24	0.12	0.46	0.11	0.44	0.03	0.08
Run × Treatment	0.03	0.02	0.01	0.20	0.01	0.39	0.12	0.22

[a] Compost applied (from 1992 to 1995) to meet annual corn nitrogen requirements (NA), biennial nitrogen requirements (NB), annual phosphorus requirements (PA), biennial phosphorus requirements (PB), annual fertilizer application (FR), and check (CK).

solution concentrations and nutrient transport were also similar for the various experimental treatments. These results would be expected from a site having little residual soil P or N. Thus, four years after the last compost application, the varying compost application rates and intervals did not appear to significantly affect the nutrient content of runoff.

Residue Effects on Nitrogen and Phosphorus Transport

The first three rainfall simulation runs occurred on plots without crop residue. The presence of crop residue could influence concentrations of P and N in runoff, especially of those constituents transported principally by sediment. Therefore, a fourth rainfall simulation run was made to evaluate the effects of corn residue on P and N transport in runoff.

The concentrations and total amounts of nutrients in runoff from the plots with and without corn residue, in general, were similar (tables 4 and 5). The mean slope at the study site was 1.02%. Because of the minimal slope, runoff and erosion amounts were similar on the residue and no–residue treatments (table 5). On sites with greater slopes and increased soil erosion potential, crop residue may have more of an impact on nutrient transport. In addition, crop residue materials would be more likely to influence nutrient transport on soils containing substantial nutrient concentrations. Crop residue materials themselves can also serve as a source of nutrients (Havis and Alberts, 1993; Schreiber, 1999).

Table 3. Effects of run and residual effects of compost and fertilizer applications on total amounts of dissolved P (DP), bioavailable P (BAP), total P, nitrate–N, ammonium–N, and total–N in runoff in 2000, and analysis of variance.

Variables[a]	DP (kg ha^{-1})	BAP (kg ha^{-1})	Total P (kg ha^{-1})	NO_3–N (kg ha^{-1})	NH_4–N (kg ha^{-1})	Total N (kg ha^{-1})
Run						
One	0.025	0.037	0.115	0.028	0.006	1.78
Two	0.033	0.050	0.145	0.021	0.006	1.75
Three	0.034	0.054	0.157	0.024	0.005	1.97
$LSD_{0.05}$	0.007	0.011	0.031	NS	NS	NS
Treatment						
NA	0.039	0.046	0.121	0.028	0.003	1.45
NB	0.037	0.065	0.158	0.007	0.010	1.84
PA	0.033	0.049	0.175	0.040	0.006	2.44
PB	0.030	0.048	0.140	0.010	0.003	3.00
FR	0.028	0.044	0.152	0.040	0.007	1.38
CK	0.017	0.031	0.089	0.023	0.004	0.90
$LSD_{0.05}$	0.010	0.016	0.043	0.014	0.002	0.85
Analysis of variance (PR > F)						
Run	0.02	0.01	0.01	0.27	0.54	0.68
Treatment	0.01	0.01	0.01	0.01	0.01	0.01
Run × Treatment	0.01	0.01	0.02	0.42	0.05	0.43

[a] Compost applied (from 1992 to 1995) to meet annual corn nitrogen requirements (NA), biennial nitrogen requirements (NB), annual phosphorus requirements (PA), biennial phosphorus requirements (PB), annual fertilizer application (FR), and check (CK).

Table 4. Effects of residue addition and residual effects of compost and fertilizer applications on concentrations of dissolved P (DP), bioavailable P (BAP), total P, nitrate–N, ammonium–N, total N, electrical conductivity (EC), and pH during the fourth rainfall simulation run in 2000, and analysis of variance.

Variables[a]	DP (mg L^{-1})	BAP (mg L^{-1})	Total P (mg L^{-1})	NO_3–N (mg L^{-1})	NH_4–N (mg L^{-1})	Total N (mg L^{-1})	EC (d S m^{-1})	pH
Residue addition								
Residue	0.26	0.39	1.33	0.43	0.07	19.17	0.65	7.71
No–residue	0.32	0.48	1.70	0.32	0.06	21.10	0.65	7.61
$LSD_{0.05}$	0.05	0.06	0.20	NS	NS	NS	NS	NS
Treatment								
NA	0.36	0.35	1.09	0.21	0.10	14.00	0.66	7.91
NB	0.35	0.61	1.65	0.27	0.08	21.63	0.64	7.66
PA	0.28	0.42	2.57	0.58	0.08	31.67	0.65	7.52
PB	0.23	0.38	1.04	0.32	0.03	25.75	0.65	7.54
FR	0.33	0.46	1.43	0.63	0.06	13.38	0.64	7.61
CK	0.19	0.39	1.33	0.25	0.03	14.38	0.63	7.71
$LSD_{0.05}$	0.09	0.10	0.38	0.26	NS	6.72	NS	0.29
Analysis of variance (PR > F)								
Residue addition	0.04	0.01	0.01	0.10	0.72	0.28	0.78	0.22
Treatment	0.01	0.01	0.01	0.01	0.35	0.01	0.61	0.04
Residue addition × Treatment	0.61	0.05	0.01	0.01	0.12	0.04	0.16	0.12

[a] Compost applied (from 1992 to 1995) to meet annual corn nitrogen requirements (NA), biennial nitrogen requirements (NB), annual phosphorus requirements (PA), biennial phosphorus requirements (PB), annual fertilizer application (FR), and check (CK).

Table 5. Effects of residue addition and residual effects of compost and fertilizer applications on total amounts of dissolved P (DP), bioavailable P (BAP), total–P, nitrate–N, ammonium–N, total N, runoff, and erosion during the fourth rainfall simulation run in 2000, and analysis of variance.

Variables[a]	DP (kg ha^{-1})	BAP (kg ha^{-1})	Total P (kg ha^{-1})	NO_3–N (kg ha^{-1})	NH_4–N (kg ha^{-1})	Total N (kg ha^{-1})	Runoff (mm)	Erosion (Mg ha^{-1})
Residue addition								
Residue	0.031	0.044	0.152	0.047	0.009	2.10	17	0.35
No–residue	0.031	0.049	0.162	0.024	0.006	1.90	15	0.35
LSD $_{0.05}$	NS	NS	NS	0.017	NS	NS	NS	NS
Treatment								
NA	0.046	0.042	0.118	0.020	0.015	1.59	15	0.17
NB	0.043	0.082	0.232	0.027	0.011	2.55	15	0.41
PA	0.019	0.028	0.194	0.048	0.006	2.52	7	0.23
PB	0.029	0.047	0.130	0.039	0.004	3.23	20	0.28
FR	0.033	0.048	0.148	0.062	0.006	1.40	22	0.53
CK	0.015	0.032	0.120	0.017	0.003	0.74	16	0.49
LSD $_{0.05}$	0.019	0.027	0.084	0.032	NS	1.09	11	NS
Analysis of variance (PR > F)								
Residue addition	0.96	0.52	0.62	0.01	0.29	0.50	0.38	0.95
Treatment	0.01	0.01	0.02	0.02	0.18	0.01	0.07	0.26
Residue addition × Treatment	0.93	0.83	0.23	0.01	0.15	0.60	0.97	0.83

[a] Compost applied (from 1992 to 1995) to meet annual corn nitrogen requirements (NA), biennial nitrogen requirements (NB), annual phosphorus requirements (PA), biennial phosphorus requirements (PB), annual fertilizer application (FR), and check (CK).

Crop residue materials have been shown to significantly impact runoff (Gilley et al., 1986). Consequently, the potential for P movement into the soil profile is increased. An elevated soil P level may result from the long–term application of manure or fertilizer (Eghball et al., 1996).

Dissolved Phosphorus in Runoff as Affected by Soil Phosphorus

Data from the plots on which compost or fertilizer were applied were used to develop the regression equations shown in figures 1 and 2. The regression relationships were derived relating DP concentration of runoff to soil test P at the 0 to 5 cm depth for Bray and Kurtz No. 1 soil test P values ranging from 42 to 267 mg kg^{-1} and water–soluble soil test P values varying from 5 to 61 mg kg^{-1}. It is apparent from figures 1 and 2 that considerable scatter occurred in the experimental data, and the DP concentration of runoff did not correlate well with soil test P.

Pote et al. (1999) found a good correlation between water–extractable P content in surface soil and dissolved reactive P concentration in runoff from three soils located in northwest Arkansas on which poultry litter had been applied to fescue (*Festuca arundinacea* Schreb.). However, Sims (2000) found that Mehlich I soil P values did not compare well to readily desorbed P. The type of vegetation, soil characteristics, and method, timing, and amount of manure application may affect P concentrations in runoff. At present, a well accepted predictive technique or relationship between most measures of soil P and P in runoff is not available.

Results from this study suggest that factors in addition to soil test P should be considered to accurately estimate P concentration of runoff from the bare Sharpsburg soil used in this investigation. Eghball et al. (1990) found that the Sharpsburg soil has a relatively high adsorption capacity for phosphorus. Since the compost or fertilizer had sufficient time to equilibrate in the soil, P release was small even at relatively high soil test P levels.

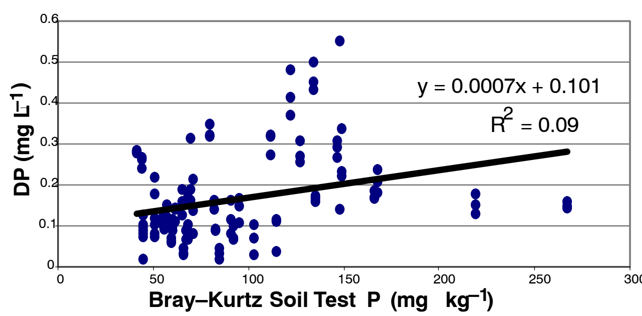

Figure 1. Relationship between the concentration of dissolved P in runoff and Bray and Kurtz No. 1 soil test P for the plots on which compost and fertilizer were applied.

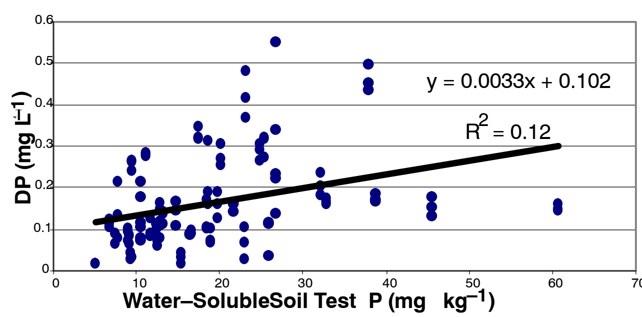

Figure 2. Relationship between the concentration of dissolved P in runoff and water–soluble soil test P for the plots on which compost and fertilizer were applied.

Conclusions

The following conclusions can be drawn from this study:

- After four years of corn production following the last compost application, soil P content, EC, and pH of the surface soils on the N–based compost treatments were significantly greater than those on the check plots.
- Four years following application of compost on an annual or biennial schedule to meet P or N requirements for corn, concentrations and total amounts of P and N in runoff were similar on the compost and inorganic fertilizer plots.
- The addition of corn residue at a rate of 6 Mg ha^{-1} did not significantly affect the nutrient concentration of runoff or total nutrient transport when compared with the no–residue condition, for a study site with a slope varying from 0.15% to 2.70%.
- The DP concentration of runoff did not correlate well with soil test P for Bray and Kurtz No. 1 soil test P values ranging from 42 to 267 mg kg^{-1} or water–soluble soil test P values varying from 5 to 61 mg kg^{-1}.

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