Final Report to the Iowa Egg Council

Phosphorus Loss With Surface Runoff Shortly After Application of Poultry Manure and Fertilizer Without Incorporation Into the Soil

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Review of Research Objectives

The general goal of this two-year study was to test the hypothesis that the risk of phosphorus (P) loss with surface runoff shortly after P application without incorporation into the soil is less for poultry manure than for fertilizer. Much of the fertilizer and poultry manure being applied to Iowa fields is spread in the fall and is not incorporated into the soil until spring or is not when no-till management is used. The currently assumed risk of runoff P loss in Iowa is similar for all P sources. Therefore, objectives were to study short-term P loss with runoff when different types of poultry manure or fertilizer are applied without incorporation into the soil under similar conditions. To achieve the goals and objectives of the study we conducted field and laboratory research during two years.

Summary of Procedures

Poultry manure was collected from egg layers, broilers, and turkey facilities. Farmers interested in cooperating with the project provided the manure, and the field work was conducted at their fields or at other fields when their fields were not suitable for the project (for example, due to insufficient slope or difficult access or undesirable crop residue). Manure of the same type but from different feeding operations was used at each field. We applied manure from broilers, egg layers, and turkeys. The production and feeding management at the facilities varied considerably and determined a wide range of commonly found manure moisture content, diets, use of phytase feeding, addition of egg shells, etc. We worked on 17 fields in the 2-year of the project. There were five rainfall simulations in fall 2006, six in spring 2007, and six in fall 2007. The fields were in Story (2 fields), Taylor, Wright (2 fields), Union (5 fields), Hamilton (3 fields), Washington (2 fields), and Fayettee (2 fields) counties. Locations and results of selected soil analyses are presented in Table 1. In the fall the runoff rainfall simulation work started immediately after harvest and continued until the middle of November, while in spring the work was conducted from late March to early May depending on weather conditions. These two periods were of very intense field activities each year. Laboratory work and outreach activities continued until June 30, 2008.

Soil samples were collected before P application from depths of 0-2 and 2-6 inches. Five treatments replicated three times were applied to all fields. A rate of 100 lb total P_2O_5/acre was applied with the three manure types (broilers, egg layers, and turkeys) or fertilizer (DAP), and a control receiving no P. The manure was analyzed for moisture content; soluble P; total P, N, K, and carbon; and pH. The treatments were applied to fields with approximately 2.5 to 7% slope and soybean residue without previous tillage or incorporation into the soil. Simulated rainfall was applied within 24 hours of treatments using field rainfall simulation equipment and techniques we already used in previous Iowa projects. The equipment and procedures are those suggested by the National Runoff P Project, of which the investigators have been participating. Simulated rainfall was applied within 24 hours of applying manure and fertilizer treatments to get 30 minutes of continuous runoff. The runoff was analyzed for the three most important P fractions: dissolved reactive P (DRP), total P, and bioavailable P (BAP). The DRP runoff P fraction is readily available for algae growth in streams or lakes, the biovailable P results from a laboratory analysis that estimates P readily available to algae plus that available over a short period of time (weeks or a few months). The project and its objectives, the value of poultry manure P for crops, and environmental P issues were explained and discussed before and during these field activities to the producers.

Highlights of the Results

Results of analysis of soil samples collected before P application showed that levels of soil-test P, pH, organic matter and other routine tests varied greatly across fields. For example, average site results for a 6-inch sampling depth shown in Table 1 ranged from 5.7 to 7.8 for pH and 10 to 264 ppm for Bray-1 P (Low to Very High interpretation classes). The results of manure moisture, total P, and soluble P analyses are shown in Table 2. For broilers the range for manure moisture was 18 to 67%, for total P concentration was 20 to 84 lb P_2O_5/ton (wet basis), and for water-soluble P concentration was 6 to 28 P_2O_5/ton (wet basis). Ranges for egg layers manure were 13-76%, 9-111 lb P_2O_5/ton, and 5-22 lb P_2O_5/ton, respectively. Ranges for turkey manure were 23-60%, 31-99 lb P_2O_5/ton, and 10-31 lb P_2O_5/ton, respectively. These values confirmed the large variation in manure analysis results that is commonly observed by producers and clearly show the need for manure testing instead of relying on average tabulated values.

The results from the field runoff rainfall simulations varied greatly across fields and replications within a field as is always the case with manure. General patterns were very obvious, however. Application of P with any source sharply increased P concentration in runoff compared with the control receiving no P in all fields. Correlations for the control treatment across sites (not shown) indicated that that the three fractions of runoff P increased with increasing soil P measured by various methods. When the P sources were compared, the runoff P concentration was much higher for fertilizer than for the manure sources. Data in Figures 1, 2, and 3 summarize the results of runoff P concentrations by season and Figure 4 shows averages across the 17 fields. Study of results for the individual fields (not shown) indicated that the differences among manure from broilers, egg layers, and turkeys were small and inconsistent across fields. This was reflected in small differences between the three manure types for averages for each season in Figures 1, 2, and 3. There were also small differences between manure sources within a manure type (across feeding operations). These small and inconsistent differences were explained mostly by the physical form of the materials (mainly moisture and litter content) and in part by the proportion of soluble P of the total manure P.

The treatment rankings for P loads usually followed trends for concentrations but were more variable because of high variation in runoff volume. Results for loads averaged for each season and across the 17 fields are shown in Figures 5 through 8. The P loads for all fractions and P sources differed greatly among sites and seasons mainly due to differences in local hydrologic conditions. The higher P load for the fertilizer treatments was very obvious, and similarly to runoff P concentrations there were much smaller differences among the three poultry manure types. Iowa long-term precipitation data indicates a very low probability of runoff-causing rainfall events in the fall season and a very high probability in spring. Therefore, results for spring likely represent better the total P losses that may occur for these P sources during the year under natural rainfall.

The obvious large differences in runoff P between fertilizer and the manures, consistent for each season and the average across all fields, can be partly explained by a larger solubility of P compounds in the fertilizer. However, results also could have been influenced by largely undetermined effects of the physical form of the manure sources modifying the impact of rainfall on P release from both the materials applied and the soil. This is because the manure sources sometimes had wide variation in soluble P concentration within and across manure types, but this measurement was very poorly correlated with dissolved or total runoff P across sites. This poor correlation has also being observed in a previous poultry manure project. Intense research is being conducted at this time, in part by more thorough analysis of results of this project, to determine the value of measuring the proportion of soluble P in manure in relation to impacts on runoff P loss. A previous Iowa project showed that the proportion of soluble P in poultry manure was not correlated to manure P availability for crops.

At this time we continue study and statistical analyses of manure, runoff, and soil results to further analyze and interpret the results for a more complete publication. Therefore, the results in this report should be considered preliminary and recommend much caution when interpreting them. Also, this type of experiments involves simulating rainfall for a one-time measurement of runoff volume and runoff P when in practice any P loss depends on the probability of a heavy rainfall immediately after application and on transport actors that greatly affect edge of field sediment and P losses. For example, results of a previous project with fertilizer, poultry manure, and liquid swine manure showed that both overall P losses and differences between P sources were greatly reduced when the runoff events are delayed after application with or without P incorporation into the soil. Therefore, results from field rainfall simulations are appropriate and very useful to study the potential for short-term differences in dissolved, biovailable P, or total P concentration in runoff and compare results across fields or P sources. However, this technique does not reliably describe or predict total P loss from edge of fields or long-term losses. Further research under natural rainfall and larger plots is needed to confirm if the relative differences observed in this study are maintained for a longer period of time and at field or watershed scales.

Outreach Activities

At the end of each season and as data became available the results of manure, soil, and runoff analyses were sent to each manure supplier and collaborating farmers. No other major outreach activities showing specific results of the study could be conducted yet because we did not want to share one-year results and complete results from the two years became available on time to prepare this report. However, the objectives and methods of the study were shared at several extension meetings conducted in the fall and in the winter and in two field days that focused on the value and management of animal manure nutrients.

Summary and Conclusions

Much of the fertilizer and poultry manure being applied to Iowa fields is spread in the fall and is not incorporated into the soil until spring or is not incorporated when no-till management is used. The currently assumed risk of runoff P loss in Iowa is similar for all P sources. This project evaluated and demonstrated the impact of applying a similar P rate using three poultry manure types and fertilizer P on dissolved P, bioavailable P, and total P short-term losses with surface runoff. The study was conducted on 17 Iowa producers' fields and was based on a field rainfall simulation technique. Application of 100 lb P_2O_5 with any source and without incorporation into the soils sharply increased P concentration in runoff compared with the control receiving no P in all fields. When the P sources were compared, concentrations and loads of the three runoff P fractions were much larger for fertilizer than for poultry manure. Differences in runoff P concentrations and loads resulting from applying manure from egg layers, broilers, or turkeys were small and inconsistent across fields and feeding operation sources. The differences in runoff between fertilizer and poultry manure were explained mainly by the physical form and P solubility of the materials. The study clearly demonstrated that runoff P loss for runoff events immediately after applying P without incorporation into the soil is much larger for fertilizer then for poultry manure. However, the magnitude of differences should be interpreted with caution. Further research under natural rainfall and larger plots is needed to confirm if the relative differences observed in this study are maintained for a longer period of time and at field or watershed scales.

Table 1. Locations and selected soil properties.

Site	Year	Season	County	RC	Slope	Soil Series	BP	M3P	OP	OM*	pH
				%	%		--------- ppm		-------	%	
1	2006	Fall	Story	93	2.6	Kossouth	142	164	97	5.4	6.8
2	2006	Fall	Wright	95	2.4	Okoboji	10	71	16	8.2	7.8
3	2006	Fall	Wright	91	5.1	Clarion	27	39	15	2.4	7.3
4	2006	Fall	Taylor	53	5.6	Adair	133	143	90	4.0	6.5
5	2006	Fall	Union	93	2.6	Sharpsburg	11	13	7	4.4	6.6
6	2007	Spring	Story	60	3.9	Flagler	212	289	61	3.2	6.3
7	2007	Spring	Hamilton	85	2.4	Clarion	78	85	39	4.1	6.2
8	2007	Spring	Washington	91	2.4	Wiota	80	96	40	2.9	6.9
9	2007	Spring	Washington	65	3.8	Nira	196	256	112	5.0	7.3
10	2007	Spring	Union	92	3.5	Colo-Ely	27	31	15	4.2	5.9
11	2007	Spring	Union	99	3.6	Nira	25	32	15	4.2	6.3
12	2007	Spring	Hamilton	88	3.6	Clarion	46	53	22	3.9	5.9
13	2007	Fall	Hamilton	87	2.7	Clarion	264	304	87	3.1	5.7
14	2007	Fall	Fayette	92	4.5	Downs	39	54	20	3.0	6.7
15	2007	Fall	Fayette	100	1.2	Schley	28	37	14	2.9	7.1
16	2007	Fall	Washington	100	1.9	Mahaska	39	47	21	4.7	6.5
17	2007	Fall	Washington	100	1.8	Nevin	144	196	75	3.1	6.5

* 6-inch depth before P application. RC, residue cover; BP, Bray-1 P, M3P, Mehlich-3 P, OP, Olsen P; OM, Organic matter.

Table 2. Selected results of manure analysis.*

	Manure from Turkeys			Manure from Broilers			Manure from Egg Layers		
Site	Total	Soluble	Moist.	Total	Soluble	Moist.	Total	Soluble	Moist.
	P_2O_5 lb/ton		%	P_2O_5 lb/ton		%	P_2O_5 lb/ton		%
1	75	19	25	44	19	58	16	8	76
2	31	12	28	62	19	48	54	12	39
3	89	16	46	56	23	42	73	13	23
4	38	10	39	44	16	64	11	15	16
5	70	18	47	76	23	58	79	19	37
6	72	20	50	65	22	36	87	22	42
7	49	18	41	60	20	61	69	17	48
8	69	20	32	80	24	18	55	18	61
9	44	18	55	38	18	67	39	14	74
10	74	17	50	57	18	64	80	12	42
11	43	12	56	71	18	37	9	14	24
12	70	18	44	68	9	24	107	21	27
13	81	17	60	63	11	20	54	5	18
14	99	31	27	20	6	25	73	21	36
15	99	30	23	49	8	19	97	17	13
16	73	18	53	84	20	26	111	20	15
17	82	18	60	84	28	22	77	10	30

* All analyses are expressed on a wet basis.

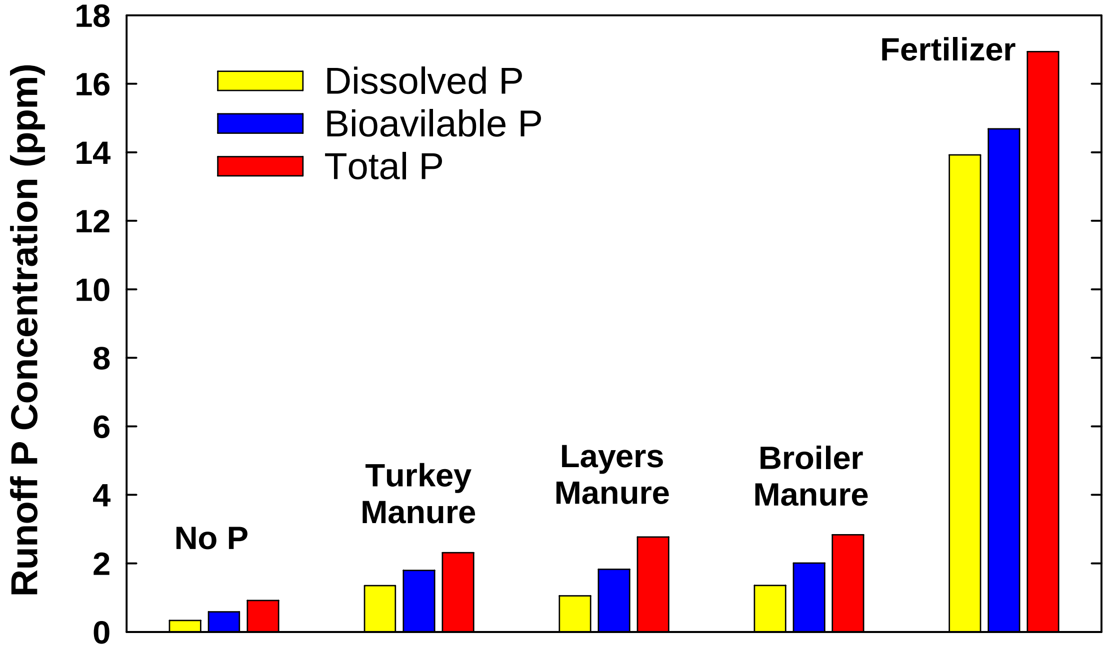

Figure 1. Average runoff P concentration across five field rainfall simulations conducted in fall 2006 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

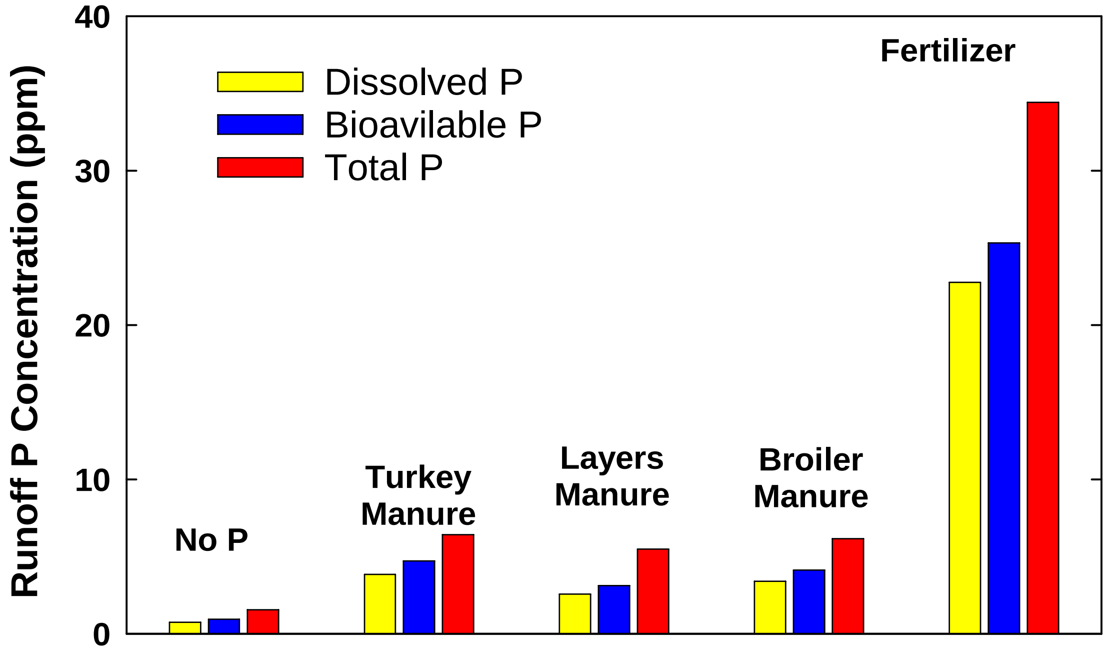

Figure. 2. Average runoff P concentrations across six field rainfall simulations conducted in spring 2007 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

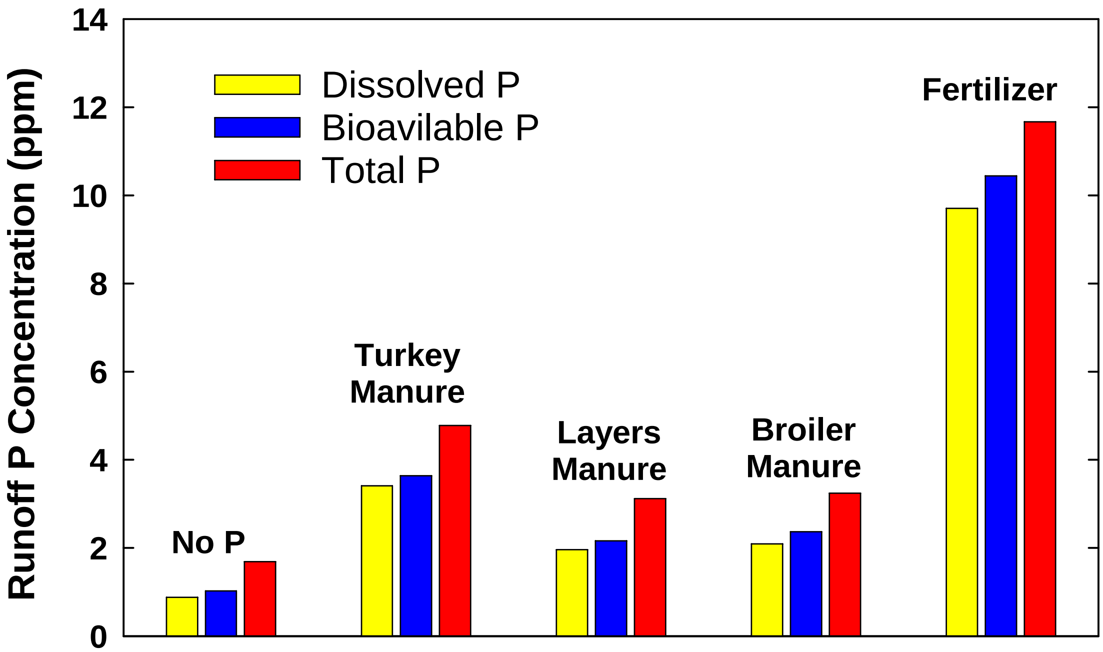

Figure 3. Average runoff P concentrations across six field rainfall simulations conducted in fall 2007 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

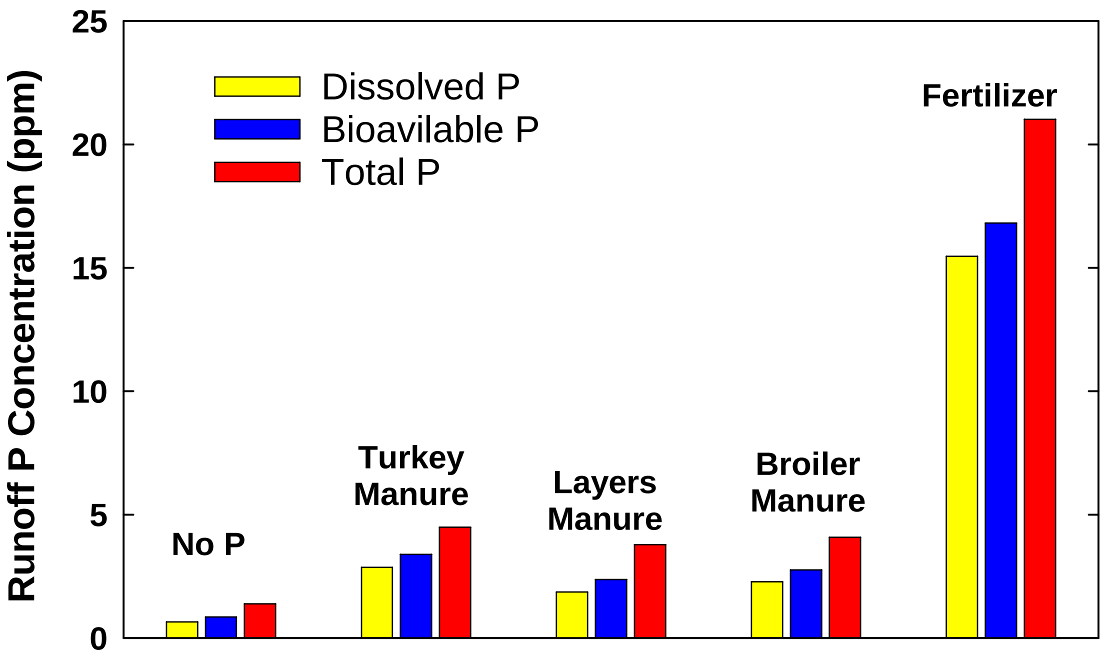

Figure 4. Average runoff P concentrations across 17 field rainfall simulations conducted during two years for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

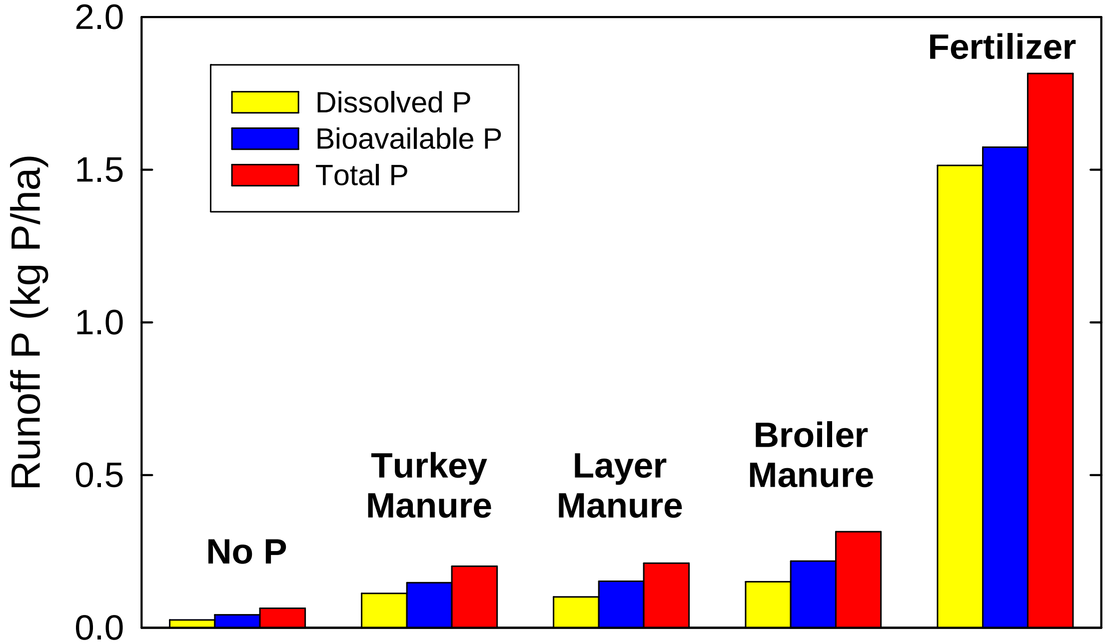

Figure 5. Average runoff P loads across five field rainfall simulations conducted in fall 2006 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

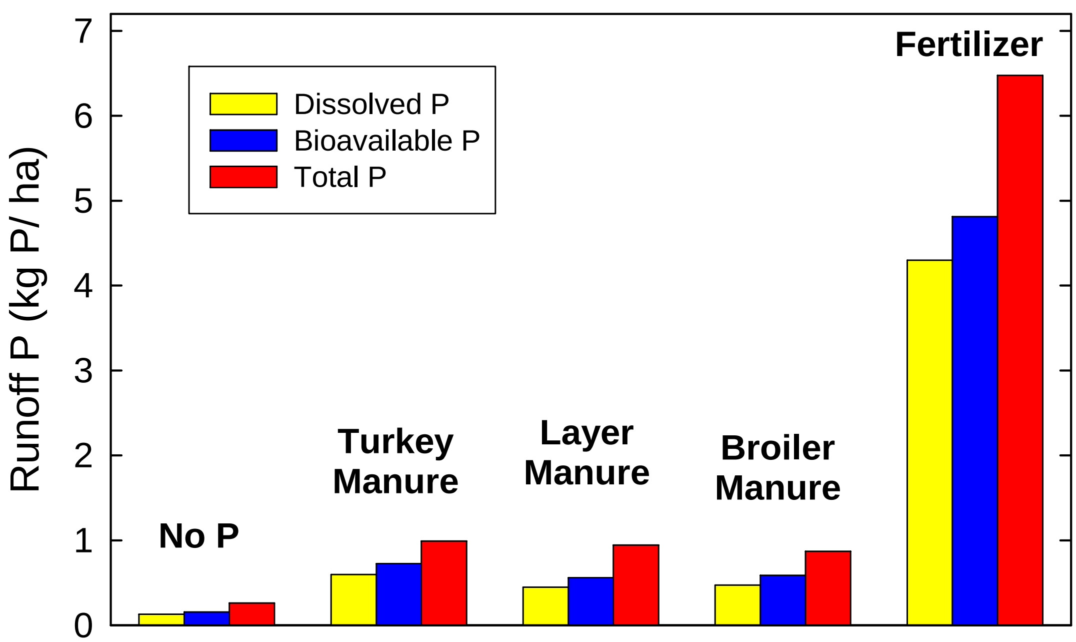

Figure 6. Average runoff P loads across six field rainfall simulations conducted in spring 2007 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

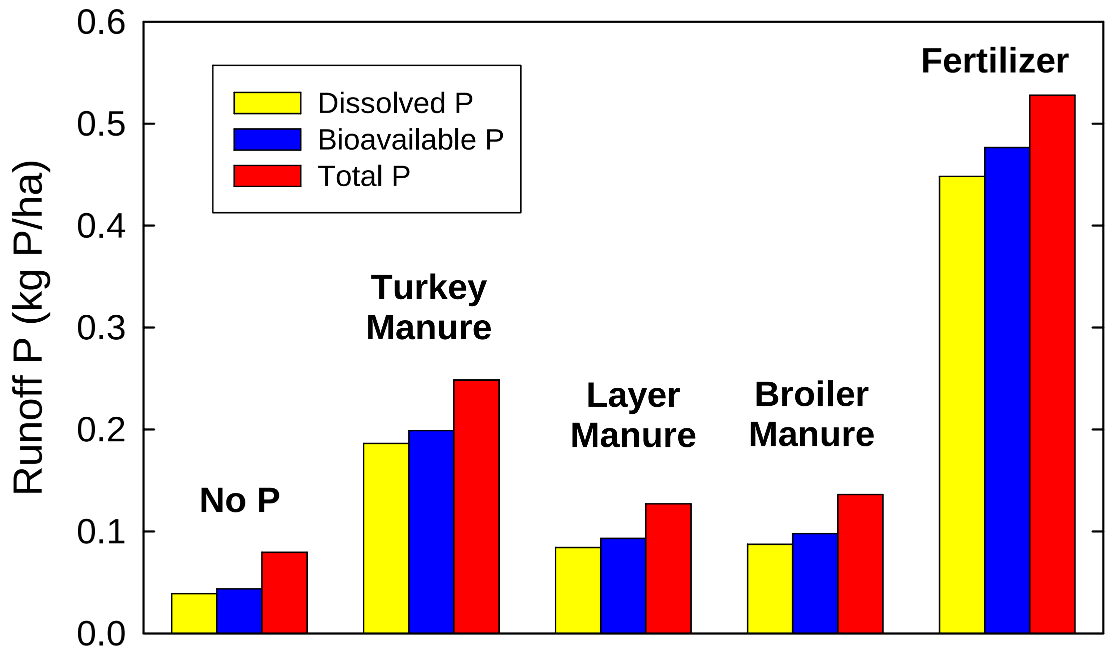

Figure 7. Average runoff P loads across six field rainfall simulations conducted in fall 2007 for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.

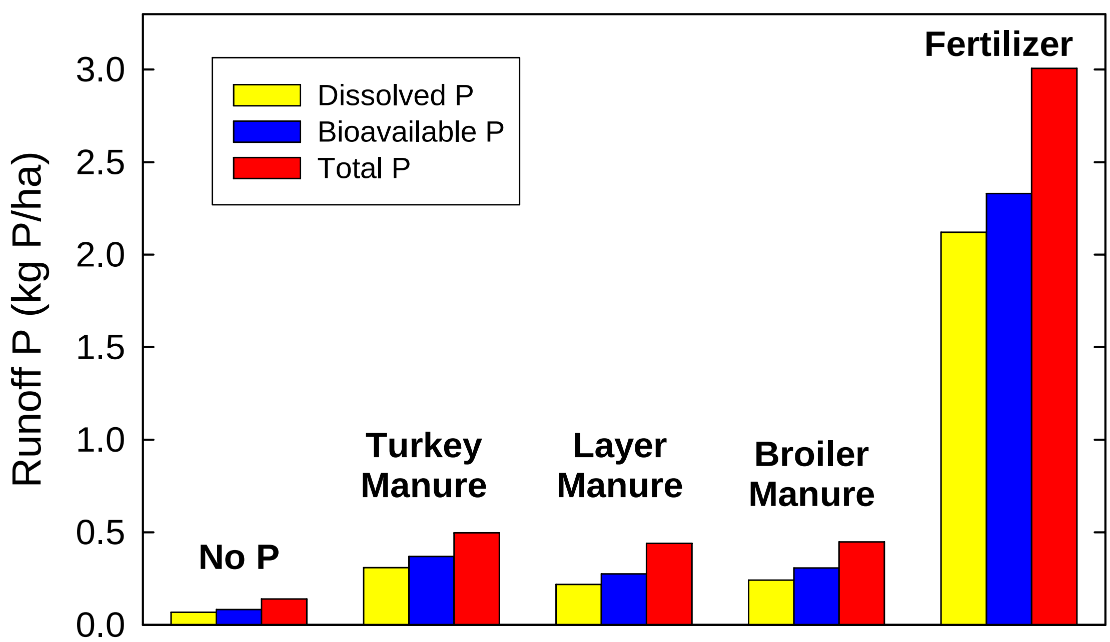

Figure 8. Average runoff P loads across 17field rainfall simulations conducted during two years for fertilizer and three poultry manure types within 24 hours of applying 100 lb P_2O_5/acre to the soil surface without tillage.