Yield and Economic Responses to Phosphorus

Higher yields and greater profits are major reasons why farmers apply P to crops. All crops need P for profitable yields. However, assessing the profitability of P fertilization is difficult. The effects last well beyond the year of application. In addition, there are many economic benefits to proper P nutrition beyond yield responses, such as earlier maturity, reduced grain moisture, and improved quality.

> The most important reason for phosphorus (P) application is to increase profit.

Corn

The data in **Table 1** show the residual effects of a large, single application of P. These data clearly show that P has residual effects upon yield beyond the year of application. Therefore, costs associated with P fertilization should be amortized over time. Without amortization, the first year net return would be minus $79.42/A, and the residual effects of P would be ignored. An amortization schedule was created by expressing the annual increase in yield as a percent of the total yield increase over the 14-year period. Expressed in this way, net returns to P are positive for each of the 14 years studied. The large response in the last year indicates that benefits would likely continue.

Research in Ohio showed corn yields increasing up to the highest rate of P_2O_5

TABLE 1. Long term effects upon corn grain yield from a large, single application of P (Iowa).

Year	Yield, bu/A 0 lb P_2O_5/A	Yield, bu/A 298 lb P_2O_5/A	Yield increase from P, bu/A	Increased yield income from P, $/A[1]	Increased harvest costs from P, $/A[2]	Amortization schedule (% of total 14 yr. yield increase from P)[3]	Amortized yearly fertilizer application costs, $/A[4]	Amortized yearly fertilizer material costs, $/A[5]	Net return to P, $/A
1976	138.0	138.9	0.9	2.03	0.32	0.3	0.02	0.22	1.47
1977	134.1	135.3	1.2	2.70	0.42	0.4	0.03	0.30	1.95
1978	150.9	157.2	6.3	14.18	2.20	2.2	0.15	1.64	10.18
1979	160.9	176.7	15.8	35.55	5.53	5.5	0.37	4.10	25.55
1980	157.9	169.9	12.0	27.00	4.20	4.2	0.29	3.13	19.39
1981	163.2	185.0	21.8	49.05	7.63	7.6	0.52	5.66	35.24
1982	145.7	179.0	33.3	74.93	11.66	11.6	0.79	8.64	53.84
1983	120.3	147.3	27.0	60.75	9.45	9.4	0.64	7.00	43.66
1984	111.2	151.8	40.6	91.35	14.21	14.1	0.96	10.50	65.68
1985	144.6	175.0	30.4	68.40	10.64	10.6	0.72	7.90	49.14
1986	116.5	157.5	41.0	92.25	14.35	14.3	0.97	10.65	66.27
1987	129.6	152.8	23.2	52.20	8.12	8.1	0.55	6.03	37.49
1988	60.2	74.6	14.4	32.40	5.04	5.0	0.34	3.73	23.30
1989	123.4	142.7	19.3	43.43	6.75	6.7	0.46	4.99	31.22
Totals			**287.2**			**100.0**	**6.80**	**74.50**	

[1]Corn price = $2.25/bu; [2]harvest costs = $0.35/bu (hauling, handling, drying); [3]calculated by dividing the annual yield increase from P by the total yield increase from P over the 14-year period; [4]calculated by multiplying a 2-trip bulk application fertilizer cost ($6.80/A) by the annual amortization percentage; [5]calculated by multiplying the P fertilizer cost ($74.50/A) by the annual amortization percentage.

TABLE 2. Corn yield increases from P fertilization (Ohio).

P_2O_5 rate, lb/A	Corn yield, bu/A
0	150
20	166
40	175
80	183
120	191

TABLE 3. Adequate P increases wheat yields (Kansas).

P_2O_5 rate, lb/A	Wheat yield, bu/A
0	27
16	48
32	52
64	60

applied on a low-testing soil (**Table 2**).

On cold, wet soils corn often responds to row applications of P. Wisconsin research showed that even on high P soils a starter application of P boosted yields by as much as 31 bu/A.

Wheat

Most soils used for wheat production need P fertilizer for profitable yields. **Table 3** shows the difference P can make in growing wheat in Kansas.

Data from Texas indicate that P placement is critical in dry years. Phosphorus placed deeper in the soil profile is more available to wheat root systems. **Table 4** shows the yield and profitability advantages of deep banded P under dry conditions.

Wheat growers see the best grain production when both nitrogen (N) and P are applied at optimum rates. In **Table 5**, data from Manitoba show the effectiveness of balanced N and P fertilization.

Soybeans

Soybeans can be quite responsive to P fertilization, as was shown on newly cleared land in Virginia (**Table 6**). The 50 lb/A of banded P_2O_5 produced a good yield response at the zero and 200 lb/A rates of broadcast P_2O_5.

In the last 10 years of a 24-year Indiana experiment, soybeans receiving both P and potassium (K) fertilizer averaged almost 54 bu/A. When P was omitted in these 10 years, average yield dropped to 44 bu/A, or an 18.5 percent reduction without P.

Cotton

Starter fertilizer containing N and P gave consistent increases in lint yields of cotton on 18 locations over a two-year period in Mississippi. Phosphorus was found to be the nutrient producing the yield response at two locations where nutrient effects were separated, shown in **Table 7**.

Five advantages to using starter fertilizer

TABLE 4. Winter wheat responds in dry years to 40 lb P_2O_5/A placed in a deep band (Texas).

Location	Year	Fertilizer application method	Winter wheat yield, bu/A	Increased yield from P, bu/A[1]	Increased income from P, $/A	Total expenses from P, $/A[2]	Net return to P, $/A
Runnels	1988	Deep P+N	31.0	10.2	28.05	15.53	12.52
		Surface P+N	25.8	5.0	13.75	14.15	-0.40
		N only	20.8				
Wichita	1995	Deep P+N	16.4	11.6	31.90	15.74	16.16
		Surface P+N	5.1	0.3	0.83	13.45	-12.62
		N only	4.8				
Abilene	1996	Deep P+N	22.0	9.8	26.95	15.47	11.48
		Surface P+N	13.2	1.0	2.75	13.55	-10.80
		N only	12.2				

[1]Winter wheat = $2.75/bu; [2]Fertilizer + application + additional harvest costs assuming $0.25/lb P_2O_5, application costs of $3.40 and $4.00/A for surface and deep, respectively, and $0.15/bu for hauling and handling.

on cotton were observed or measured: 1) enhances the development of a better early root system; 2) helps overcome early adverse conditions; 3) initiates earlier fruiting; 4) hastens maturity; and 5) increases yields.

TABLE 5. Both N and P are needed for optimum wheat yields (Manitoba).

N rate, lb/A	P_2O_5 rate, lb/A 0	18	45	Response to P, bu/A
	Wheat yield, bu/A			
0	14	17	20	6
54	41	42	46	5
107	47	54	64	17
Response to N	33	37	44	

Grain Sorghum

Grain sorghum gave outstanding yield responses to starter P in a three-year Kansas study on a low-P soil, as shown in **Table 8**. In the same study, there were no differences in yield responses between ortho and polyphosphate P sources.

TABLE 6. Soybean response to P on newly cleared land (Virginia).

Broadcast, P_2O_5, lb/A	Banded, P_2O_5, lb/A 0	50	Response to banded P, bu/A
	Soybean yield, bu/A		
0	16	35	19
200	35	43	8
400	43	44	1
600	44	45	1
Response to broadcast P	28	10	

Snap Beans

Snap beans responded to P fertilization in five out of seven years of studies in Tennessee. The optimum rate was found to be about 50 lb/A P_2O_5. Higher rates sometimes depressed yields due to a possible induced zinc (Zn) deficiency. Zinc fertilization corrects such deficiencies.

TABLE 7. Effect of no starter, N starter, and N-P starter on lint cotton yield (Mississippi).

Location	No starter	N only	N-P starter
	Lint yield, lb/A		
Webb	815	796	905
Glendora	1,033	975	1,170

Potatoes

Growers know that P is an essential component of growing profitable potatoes. Yield responses to P are common even on high P soils. For example, potato yields dropped from 320 cwt/A to 239 cwt/A when 100 lb/A of P_2O_5 was omitted from the optimum fertilizer treatment in a New Jersey trial on a high P soil. Workers in Idaho found banded P not as effective as plowdown or disking in producing highest tuber yields.

TABLE 8. Starter P boosts grain sorghum yields (Kansas).

P_2O_5 rate, lb/A	Grain sorghum yield, bu/A
0	80
18	111
36	117

Alfalfa

Alfalfa removes about 12 lb of P_2O_5 for every ton of hay harvested. This high demand for P creates conditions for large and profitable yield increases to P fertilization. A long-term study in Kansas showed alfalfa response to P at various rates (**Table 9**). BC

TABLE 9. Effect of P fertilization on alfalfa yield (Kansas).

P_2O_5, lb/A annual	Alfalfa yield, tons/A Year 1	2	3	4	5	6
0	8.1	7.7	7.4	7.1	9.1	8.2
40	9.3	9.3	8.9	8.5	10.6	9.7
80	9.3	9.7	9.5	8.8	11.4	10.4
120	9.6	10.6	10.0	9.5	12.1	11.4