Economics of a One-Time Phosphorus Application in the Northern Great Plains

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Abstract. Grain yield and protein data from a long-term P fertilizer study initiated in 1967 and continued through 1983, on a Williams loam with a soil test P of 6 mg P/kg soil (6 ppm), were economically analyzed to determine the potential benefits of a one-time P fertilizer application. Fertilizer treatments were 0, 45, and 90 kg N/ha (0, 40, and 80 lb N/A) as main plots and one-time broadcast applications of P fertilizer at study initiation of 0, 22, 45, 90 and 180 kg P/ha (0, 20, 40, 80 and 160 lb P/A) as subplots in a split-plot design. Current crop prices, interest rates, and production costs were used to estimate net returns above that of the check treatment due to N and P fertilization. Nitrogen fertilization without added P resulted in a net loss when averaged over 11 crops. Over the long term, the 45 kg N/ha plus 90 kg P/ha treatment had the greatest net return at both the 6.25 and 12.0% real interest rates at both high and low grain and N prices. Generally, net returns increased as the level of initial P fertilizer application increased at all N levels. Premiums paid for grain protein in wheat in the northern Great Plains can potentially pay for 50–75% of the fertilizer N added. Profits were optimized when N and P fertilization practices resulted in a good balance of available N and P in the soil with an average net return per crop on a long-term basis of $44/ha ($18/A) for the higher P application rates with adequate N.

Introduction

Phosphorus is one of the major limiting plant nutrients in glacial till soils of the northern Great Plains. Crop yields are generally increased by P fertilization on soils testing "low" in plant-available P. The value of residual fertilizer P in increasing crop yields has been reported for several studies in the northern Great Plains [1, 2, 4, 9]. Few of these studies have considered the economic benefits resulting from the positive effects of residual P fertilizer on crop yields. Jose [7] found that a one-time, large-broadcast P application had an economic advantage over annual smaller P applications in spring grain cropping systems in Canada.

The current emphasis on the need for higher fertilizer rates to optimize grain yields necessitates that the short- and long-term economic impact of these fertilizer applications be evaluated. Recently, Halvorson and Black [4, 5] completed a long-term (17 year) residual P fertilizer study. The purpose of this study was to evaluate the impact of N and P fertilization on the economics of dryland crop production using current crop prices and fertilizer costs and the crop yield data reported by Black [2] and Halvorson and Black [4]. This study addresses the cumulative change in fertilized yield minus the check plot yield (zero N and P fertilizer) for each treatment. In this paper, we are interested only in testing the economics of a one-time broadcast P application and not in comparing it to other methods of P application.

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Materials and Methods

Agronomic Factors

Crop yield and protein data were collected from 1967 to 1983 from an N-and-P fertilizer study conducted near Culbertson, Montana, on a glacial till Williams loam soil (fine-loamy mixed, Typic Argiboroll). Identical sets of plots, one established in 1967 and one in 1968 on summer fallow, were cropped for 11 and 10 years, respectively. After the sixth crop in a crop-fallow sequence (1967/68 to 1977/78), the plots were annually cropped through 1983. Table 1 shows the cropping sequence and N fertilizer applied, above that of the check plot, each crop year. Average yield data for the first 10 crops for both series plus the 11th crop from the 1967 series were used in this analysis.

Fertilizer N rates of 0, 45, and 90 kg N/ha per year (0, 40, and 80 lb N/A; N1, N2, and N3, respectively) were main plots with P rates of 0, 22, 45, 90, and 180 kg P/ha

Table 1. Cropping sequence and additional N fertilizer applied above that of the check treatment (N1 plus P1).

Year	Crop[a]	Fertilizer N added, kg/ha[c]		
		N1	N2	N3
	1967 Plot series			
1967	Spring wheat	0	45	90
1969	Spring wheat	0	45	90
1971	Spring wheat	0	45	90
1973	Spring wheat	0	45	90
1975	Spring wheat	0	45	90
1977	Spring wheat	0	45	90
1978	Safflower	0	0	0
1979	Spring barley	0	0	0
1980	Winter wheat[b]	0	0	0
1981	Winter wheat	0	0	0
1982	Spring barley	0	45	90
1983	Spring wheat	0	45	90
	1968 Plot series			
1968	Spring wheat	0	45	90
1970	Spring wheat	0	45	90
1972	Spring wheat	0	45	90
1974	Spring wheat	0	45	90
1976	Spring wheat	0	45	90
1978	Winter wheat	0	45	90
1979	Safflower	0	0	0
1980	Fallow (drought)	0	0	0
1981	Spring barley	0	0	0
1982	Spring wheat	0	45	90
1983	Winter wheat	0	45	90

[a] Spring wheat—*Triticum aestivum* L.; winter wheat—*Triticum aestivum* L.; spring barley—*Hordeum vulgare* L.; safflower—*Charthamus tinctorius* L.
[b] Winter wheat crop destroyed in June owing to severe drought.
[c] lb N/acre = (kg N/ha)/1.12.

(0, 20, 40, 80, and 160 lb P/A; P1, P2, P3, P4, and P5, respectively) as subplots in a split-plot design. Fertilizer P was applied only once to each P treatment, at initiation of each plot series in 1967 or 1968. The fertilizer P was broadcast and incorporated into the soil with a disk to a depth of about 7 cm (3 inches). All other tillage operations during the course of the study were performed at a depth of 5–7 cm. The N treatments were applied each crop year except to the seventh, eighth, and ninth crops of the 1967 plot series and the seventh and eighth crops of the 1968 plot series, because a large quantity of residual NO_3-N had accumulated in the soil profile by the end of the sixth crop-fallow cycle in the N2 and N3 treatments [8]. Therefore, all plots were cropped annually for several seasons without additional fertilizer N. More specific agronomic details about the study have been presented by Black [2] and Halvorson and Black [4–6]. The statistical analysis of the yield data has been reported previously by Halvorson and Black [4].

Economic Factors

Economic factors considered in this analysis included crop prices, fertilizer purchase and application costs, protein premiums, federal income taxes, and real interest rates. A baseline grain price of $0.121/kg grain ($3.30/bu of wheat) was used because this is the average U.S. loan price for hard red spring wheat. The loan price provides a floor for the market price of wheat because producers that participate in the farm program can transfer wheat to the government at this price. To keep the analysis in wheat equivalents, the same price was assumed per kilogram of safflower and barley.

The average price paid for P fertilizer in North Dakota in 1984 of $1.035/kg P ($0.47/lb P) was used in the baseline analysis. A cost of $0.51/kg N was used for granular N fertilizer for the first year of fertilizer application with a broadcast application cost of $6.03/ha ($2.44/A). All subsequent N fertilizer applications were assumed to be anhydrous ammonia with a cost of $0.35/kg N and a knifed application cost of $10.37/ha. These average fertilizer and application costs for North Dakota were taken from Reff [10, 11]. Assumed custom rates for fertilizer application were based on a 1984 survey of custom applicators in North Dakota [10]. The costs resulting from handling increased grain yields were not considered in this analysis because they would be difficult to calculate and were considered insignificant compared to other costs.

The cumulative economic benefits over time were considered by using the discounted cash flow concept [3]. A discount rate of 6.25% was used to compare the economic benefits for all years on a net, present-value basis. This approach was necessary since a dollar today is worth more than a dollar anytime in the future because of "the time preference for money." The discount formula used was

$$\text{Discount value} = (1/(1 + R)^n)$$

where n = number of years and R = discount rate. A 6.25% discount rate was chosen because it reflects the real interest rate which is the nominal interest rate minus the inflation rate. Since no inflation factor was used in fertilizer or grain prices, an interest rate excluding the inflation premium was appropriate. For example, a 10.25% nominal interest rate minus a 4.00% inflation rate equals a 6.25% real interest rate. An additional analysis was conducted using a 12% discount rate.

A maximum potential federal income tax savings from the one-time application of P fertilizer was estimated by assuming a 50% tax bracket for crop year 1 only and a zero percent tax bracket for crop years 2 through 11. The tax savings would be greater if state and self-employment taxes were also included. This tax savings is shown to illustrate the added benefit if an individual, for whatever reason, had a very high taxable income year. Income taxes in all other years were assumed to be zero to reflect the findings of Pederson et al. [8] that the median-income farmer in North Dakota pays zero federal income taxes. Only the variable costs (P and N fertilizer plus application cost) in crop year 1 were used in calculating the tax savings. The value of the grain protein with each wheat crop was considered in a separate analysis. The value of the protein was estimated from the long-term history

Table 2. Grain yield of the check treatment each year and cumulative yield above check treatment with each additional crop year (average of 1967 and 1968 plot series) for the various N and P treatments.

N	Total P added (kg/ha)	Crop year 1	2	3	4	5	6	7	8	9	10	11
		Check yield, kg/ha										
1	0	2,077	1,226	2,374	1,509	2,126	1,364	1,148	2,117	1,579	1,174	997
		Cumulative yield above check, kg/ha										
1	0	0	0	0	0	0	0	0	0	0	0	0
1	22	401	446	503	624	926	1055	1,124	1,096	1,115	1,064	971
1	45	469	812	1,104	1,179	1,700	1,821	2,086	2,041	2,038	1,929	1,857
1	90	521	847	1,285	1,472	2,141	2,538	2,790	2,687	2,742	2,614	1,554
1	180	651	1,204	1,825	2,063	2,729	3,214	3,487	3,420	3,552	3,320	3,354
2	0	−116	−32	36	32	414	280	694	498	774	1,571	1,911
2	22	510	904	1,030	1,037	1,561	1,539	2,238	2,308	2,727	3,525	3,747
2	45	784	1,364	1,766	2,017	2,965	3,361	3,928	3,985	4,392	5,251	5,758
2	90	822	1,622	2,446	3,014	4,361	5,293	5,889	6,095	6,591	7,540	8,027
2	180	896	1,801	2,611	3,244	4,693	5,872	6,420	6,701	7,359	8,411	8,928
3	0	−142	−20	82	11	520	496	1,130	1,118	1,376	2,217	2,818
3	22	434	753	973	991	1,720	1,862	2,542	2,572	2,858	3,664	4,123
3	45	665	1,230	1,861	2,086	3,121	3,557	4,225	4,348	4,671	5,620	6,261
3	90	722	1,658	2,521	3,041	4,269	5,195	5,759	5,794	6,260	7,304	7,926
3	180	786	1,837	2,819	3,326	4,656	5,982	6,694	6,947	7,679	8,870	9,567

Note: (kg/ha)/1.12 = lb/A.

(1965 to 1984) for protein premiums actually paid by grain elevators in North Dakota [12]. At a concentration of 120 g protein/kg grain (12%), the protein premium was assumed to be zero. At a concentration of 170 g protein/kg grain, the protein premium was valued at $17/Mg of grain (0.46/bu). No additional protein premium was considered above 170 g/kg, nor was a price discount considered below 120 g/kg. A linear relationship was developed for wheat to reflect the increase in grain value as grain protein increased from120 to 170 g protein/kg using the following formula:

$$PP = PC(0.34) - 40.69$$

where PP = protein premium in $/Mg grain and PC = protein concentration in g protein/kg grain.

In this study, the discounted economic returns over P and N fertilizer plus application costs were analyzed. The residual or net income is what is left over to pay all other operating costs including a return to labor, capital, and management.

Results and Discussion

The average cumulative yield increase over the no-fertilizer treatment for the 11 crops is shown in Table 2, which served as the data base used in this economic analysis. As reported previously [4], the N × P interaction had a definite positive effect on grain yield. The single application of 180 kg P/ha (160 lb P/A) to the first crop plus the addition of 90 kg N/ha to each succeeding crop, except as noted, resulted in the greatest cumulative grain yield above that of the check plot for this study. Following the sixth crop, the cumulative yields for all the treatments receiving no N (N1) showed little change and tended to decrease slightly during the annual cropping phase of this study.

Economics When Wheat Price = $0.121/kg ($3.30/bu)

The cumulative net returns above fertilizer cost are shown in Table 3 when wheat price = $0.121/kg, P = $1.035/kg ($0.47/lb.), N = $0.51/kg the first year and $0.35/kg all other years, and application costs of $6.01/ha ($2.43/A) the first year and $10.34/ha all other years. Without N fertilization, the P2 and P3 treatments were profitable in crop year 1, P4 in crop year 2, and P5 in crop year 3. The N2 treatment without fertilizer P did not show a net profit until crop year 11 (Table 3). The P2 and P3 treatments had a net profit in crop year 1 with the P4 and P5 treatments showing a net profit in crop years 2 and 3, respectively. The N3 treatment without fertilizer P did not show a net profit during the duration of this study (Table 3). The N3 plus P2

Table 3. Cumulative net dollar return above check treatment for the various N and P treatments with each additional crop year in nominal dollars and without tax considerations.[a]

N	Total P added (kg/ha)	Crop year 1	2	3	4	5	6	7	8	9	10	11
		Cumulative net returns, $/ha										
1	0	0	0	0	0	0	0	0	0	0	0	0
1	22	20	25	32	47	83	99	107	104	106	100	89
1	45	4	46	81	90	153	168	200	195	194	181	172
1	90	−36	3	56	79	160	208	239	226	233	217	210
1	180	−113	−47	29	58	138	197	230	222	238	210	214
2	0	−43	−59	−77	−103	−83	−126	−75	−99	−79	−8	7
2	22	10	32	21	−4	33	4	89	97	135	206	206
2	45	19	63	86	90	179	201	270	277	313	391	426
2	90	−23	48	122	165	302	388	461	485	533	621	654
2	180	−107	−23	49	99	249	365	432	466	532	634	670
3	0	−69	−96	−126	−176	−156	−201	−124	−126	−115	−55	−24
3	22	−22	−25	−41	−80	−34	−58	24	28	41	97	111
3	45	−18	9	43	29	112	123	204	219	237	310	346
3	90	−58	14	77	98	204	275	343	347	383	467	501
3	180	−143	−58	19	39	158	277	363	394	462	564	607

[a] Wheat = $0.121/kg ($3.30/bu); N = $0.51/kg ($0.23/lb) first year, NH_3-N = $0.35/kg ($0.16/lb); P = $1.035/kg ($0.47/lb); fertilizer application cost = $6.01/ha ($2.44/A) first year and $10.34/ha ($4.20/A) all other years.
Note: $/ha × 0.405 = $/A.

treatment become profitable during the annual cropping phase of the study following harvest of the seventh crop. The P3 and P4 treatments were profitable in crop year 2 and the P5 treatment in crop year 3. The treatment returning the greatest estimated net profit of $61/ha per crop above that of the check plot for the duration of this study was the 45 kg N/ha plus 180 kg P/ha treatment.

When the net profits reported in Table 3 were discounted using a 6.25% real interest rate, the net profits were decreased over the long term, but the general trends discussed above for Table 3 did not change (Table 4). However, the 45 kg N/ha plus 90 kg P/ha treatment was the most profitable over the long term, with an average per-crop net income of $44/ha above that of the check treatment when averaged over 11 crops.

When the net profits reported in Table 3 were discounted using a 12.0% real interest rate, the net profits were decreased even more than with 6.25% interest over the long term, as shown in Figure 1, at the end of the sixth and eleventh crop years. The general economic trends discussed previously for Tables 3 and 4 held except that the N3 plus P2 treatment did not become profitable until crop year 10 as compared to crop year 7 in Table 4. The 45 kg N/ha plus 90 kg P/ha treatment remained the most profitable when the opportunity cost on the money invested was increased from 6.25% to 12.0%. This treatment had an average per-crop net return of $34/ha ($14/A) above that of the check treatment when averaged over 11 crops.

A tax credit was calculated based on the assumption that a farmer had a high-income situation 1 year that extended him into the 50% tax bracket. The tax saving was taken only the first year with a 0% tax bracket assumed for crop years 2 through 11. The data in Table 3 were discounted at a 6.25% real interest rate, and the first-year tax savings were added to the net returns, with the results shown in Table 5. Without N fertilization, all fertilizer P treatments showed a net profit in crop year 1 except P5, which did not show a profit until crop year 2. The N2 and N3 treatments without P fertilization did not show a net profit during the time of this study. All treatments receiving fertilizer P showed a net profit in crop year 1, when fertilizer N was added, except for the N3 plus P5 treatment, which showed a profit in crop year 2. With these assumptions, the 45 kg N/ha (40 lb N/A) plus 180 kg P/ha treatment showed the greatest long-term net profit above that of the check treatment with an average annual net profit of $52/ha. Using this scenario, the tax savings can contribute greatly to the long-term net profits and make the economic returns to N and P fertilization even more favorable.

Table 4. Cumulative net dollar return above check treatment for the various N and P treatments with each additional crop year with a 6.25% discount rate but without tax considerations.[a]

N	Total P added (kg/ha)	Crop year 1	2	3	4	5	6	7	8	9	10	11
		Cumulative net returns, $/ha										
1	0	0	0	0	0	0	0	0	0	0	0	0
1	22	20	25	31	43	72	83	89	87	88	85	79
1	45	4	43	75	82	132	142	165	161	161	153	149
1	90	−36	1	48	67	131	166	187	179	183	174	170
1	180	−113	−50	16	40	103	147	170	165	174	158	160
2	0	−43	−58	−74	−96	−80	−111	−77	−92	−80	−39	−30
2	22	10	30	21	−0	29	8	67	72	95	136	137
2	45	19	61	81	85	154	170	218	223	245	290	309
2	90	−23	44	109	145	252	317	367	383	412	463	481
2	180	−107	−28	36	78	195	281	327	349	391	449	469
3	0	−69	−95	−121	−163	−147	−180	−127	−128	−122	−87	−70
3	22	−22	−25	−39	−72	−35	−53	4	6	15	47	54
3	45	−18	7	38	26	91	99	155	165	176	219	238
3	90	−58	10	65	83	167	219	266	269	291	340	358
3	180	−143	−63	6	22	115	203	263	283	325	384	407

[a] Wheat = $0.121/kg ($3.30/bu); N = $0.51/kg ($0.23/lb) first year, NH_3-N = $0.35/kg ($0.16/lb); P = $1.035/kg ($0.47/lb); fertilizer application cost = $6.01/ha ($2.44/A) first year and $10.34/ha ($4.20/A) all other years.
Note: $/ha × 0.405 = $/A.

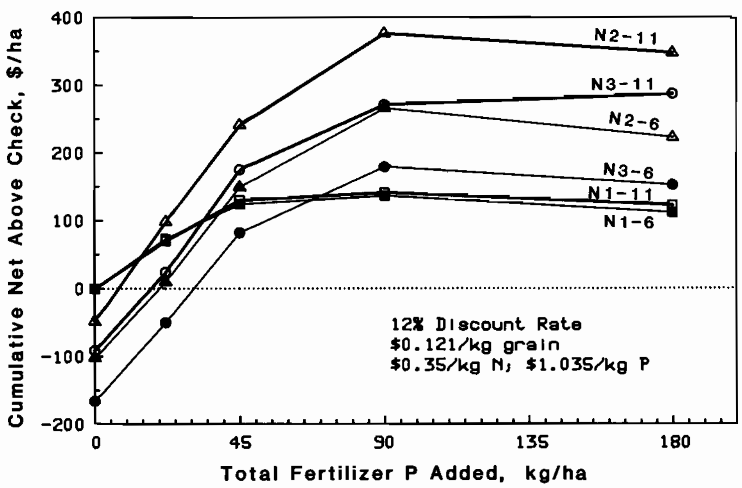

Fig. 1. Cumulative net dollar return above check treatment for each N treatment at the end of the sixth and 11th crop years as a function of initial P fertilizer applied.

Economics with Wheat Price = $0.11/kg and N = $0.705/kg

Reducing the wheat price to $0.11/kg ($3.00/bu) and increasing the cost of anhydrous ammonia to $0.705/kg N ($0.32/lb N) for crop years 2 through 11 resulted in greatly reduced net profits, as shown at the end of the sixth and eleventh crop years in figure 2. Without N fertilization (data not shown), the P2 treatment was profitable in crop year 1, P3 in crop year 2, P4 in crop year 3, and P5 in crop year 4. Generally, the N2 plus P1 or P2 treatments showed a net loss in income for much of the duration of the study. The N2 plus P3 treatment showed a net profit each crop year. The N2 plus P4 treatment was profitable in crop year 2, and the N2 plus P5 treatment in crop year 4. The N3 plus P3 treatment became profitable in crop year 10, N3 plus P4 in crop year 5, and N3 plus P5 in crop year 6. Again, the most profitable long-term treatment for this analysis was the N2 plus P4 treatment (Fig. 2), with an increase in average per crop net return above that of the check treatment of $29/ha ($12/acre) when averaged over 11 crops. The higher fer-

Table 5. Cumulative net dollar return above check treatment for the various N and P treatments with each additional crop year with a 6.25% discount rate and a 50% tax rate the first year.[a]

N	Total P added (kg/ha)	Crop year 1	2	3	4	5	6	7	8	9	10	11
		Cumulative net returns, $/ha										
1	0	0	0	0	0	0	0	0	0	0	0	0
1	22	34	39	45	58	86	98	104	101	103	99	93
1	45	30	70	101	108	158	169	191	188	187	180	175
1	90	13	51	98	117	180	216	237	229	233	224	220
1	180	−17	46	112	136	200	243	266	261	271	254	256
2	0	−28	−44	−59	−81	−66	−97	−62	−78	−65	−24	−16
2	22	36	56	47	26	55	34	92	98	121	162	163
2	45	57	99	119	122	192	208	256	260	283	328	347
2	90	38	105	170	206	314	378	428	444	473	525	542
2	180	1	79	143	185	303	389	435	457	498	557	577
3	0	−43	−69	−95	−137	−121	−154	−101	−102	−96	−61	−44
3	22	15	12	−1	−34	2	−16	41	43	52	84	92
3	45	31	56	87	75	140	148	205	214	226	268	287
3	90	15	82	138	155	239	291	229	341	363	412	430
3	180	−24	56	125	141	235	322	382	402	444	503	527

[a] Wheat = $0.121/kg ($3.30/bu); N = $0.51/kg ($0.23/lb) first year, NH_3-N = $0.35/kg ($0.16/lb); P = $1.035/kg ($0.47/lb); fertilizer application cost = $6.01/ha ($2.44/A) first year and $10.34/ha ($4.20/A) all other years.
Note: $/ha × 0.405 = $/A.

tilizer price illustrates the sensitivity of returns to either a real increase in the price of fertilizer or interest cost of operating capital. As shown in Figure 2, a good balance in available N and P is needed to obtain optimum economic returns from fertilization.

Even with a low grain price and a high price for N fertilizer, Figure 2 shows that a high rate (90–180 kg P/ha) one-time application of fertilizer P can be profitable in the long term when sufficient but not excess N is supplied to optimize grain yields.

Protein Premium

The protein concentration in the grain generally decreased with increasing level of P fertilization for all N treatments (Halvorson and Black, unpublished). Protein in the grain was increased significantly by N fertilization. The value of the grain protein premium in the eight wheat crops grown on each plot series was calculated for each year a wheat crop was grown. The average value (16 crops) of the wheat protein per crop year above that of the check treatment is shown in Figure 3 for each N and P treatment. Without N fertilization, increasing the rate of P fertilization resulted in a greater net loss per unit area because of the lower protein concentration in the grain than that of the check treatment. With N fertilization, the average protein premium per unit area increased with P fertilization. The 90 kg N/ha (80 lb N/A) plus 90 kg P/ha treatment had the greatest estimated average return per crop, $18/ha ($7/A), as a result of the protein premium. This increase in grain value due to N fertilization will help offset the cost of the N fertilizer.

The value of the grain protein was not considered in Tables 3 through 5 or in Figures 1 and 2; therefore, the potential net profits reported in these tables or figures would be greater for the N2 and N3 treatments if the protein benefits were included in the total net return. The cumulative value of the protein premiums paid for wheat, when added to the cumulative net returns shown in Table 3 and discounted at 6.25% (Table 6), result in about an $80/ha greater cumulative net return for the P4 and P5 treatments with 45 kg N/ha (Table 4 vs. Table 6). The protein premium increased the cumulative net returns of the P4 and P5 treatments with 90 kg N/ha by about $122/ha.

Summary and Conclusions

This economic analysis indicates that a one-time, high-rate (90 kg P/ha), broadcast-incorporated P fertilizer application resulted in long-term profitable net returns with adequate N fertilization. In gen-

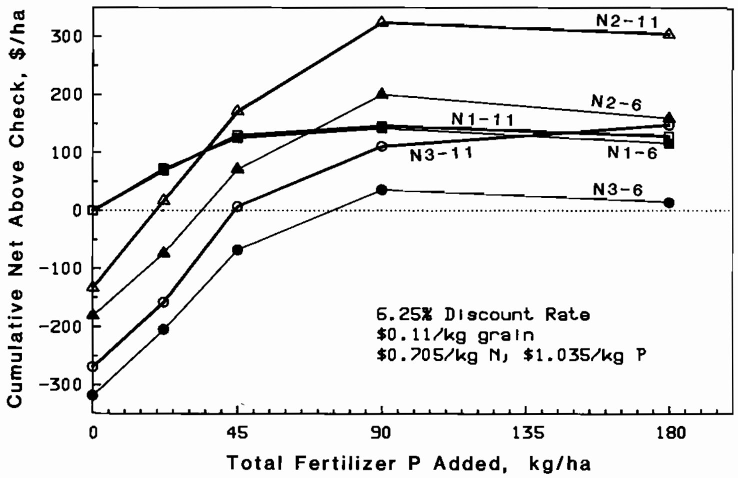

Fig. 2. Cumulative net dollar return above check treatment for each N treatment at the end of the sixth and 11th crop years as a function of initial P fertilizer applied with a reduction in grain price and increase in N price.

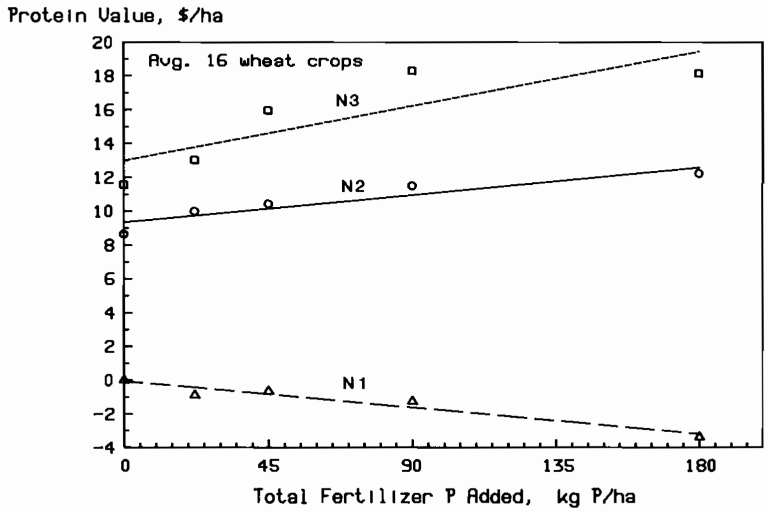

Fig. 3. Average value of grain protein premium above that of check treatment per wheat crop for the various N and P fertilizer treatments.

eral, as the rate of initial P fertilization increased, the long-term cumulative net profits due to P fertilization increased.

The most profitable fertilizer treatment in this analysis was 45 kg N/ha (40 lb N/A) applied with each crop plus 90 kg P/ha (80 lb P/A) applied once at the beginning of the study. This treatment had an average net return above that of the check treatment of $44/ha ($18/A) per crop when money was discounted at a rate of 6.25% and $34/ha ($14/A) with a discount rate of 12.0% with a wheat price of $0.121/kg ($3.30/bu) and an anhydrous ammonia cost of $0.35/kg N ($0.16/lb). Assuming a 50% tax bracket and a 6.25% discount rate, adding the income tax savings for the N and P fertilizer costs the first year resulted in an average per-crop net return of $49/ha above that of the check treatment for the 45 kg N/ha plus 90 kg P/ha treatment. This economic analysis shows that interest rate and income tax bracket can greatly influence the potential net returns due to fertilization.

Reducing the price of wheat to $0.11/kg ($3/bu) and increasing the anhydrous ammonia price to $0.705/kg N ($0.32/lb) reduced the profitability of all fertilizer treatments. However, the 45 kg N/ha plus 90 kg P/ha treatment still had the greatest cumulative net return above the check treatment and showed a positive net return after the first year, when the money was discounted at a rate of 6.25% without a tax savings. The average per crop net return above that of the check treatment was $29/ha for the 45 kg N/ha plus 90 kg P/ha treatment under the above conditions. Reducing the grain price and increasing the fertilizer cost reduced the net dollar return, but the trends were the same.

Protein premiums paid for grain protein concentrations above 120 g protein/kg grain (12%) in hard red spring wheat in the northern Great Plains can

Table 6. Cumulative net dollar return, including protein premiums, above check treatment for the various N and P treatments with each additional crop year with a 6.25% discount rate but without tax considerations.[a]

N	Total P added (kg/ha)	Crop year 1	2	3	4	5	6	7	8	9	10	11
		Cumulative net returns, $/ha										
1	0	0	0	0	0	0	0	0	0	0	0	0
1	22	12	19	25	37	67	80	85	83	83	79	72
1	45	−3	39	71	81	130	142	164	161	157	150	144
1	90	−46	−8	38	58	125	163	185	176	174	165	162
1	180	−123	−61	−1	23	87	132	155	150	152	136	138
2	0	−38	−44	−47	−66	−36	−65	−30	−45	−29	13	28
2	22	19	46	48	32	77	59	118	123	153	196	203
2	45	26	78	109	118	204	225	273	277	305	352	380
2	90	−18	58	140	186	316	386	437	453	483	536	559
2	180	−95	−8	70	123	263	358	404	426	467	527	553
3	0	−63	−78	−89	−126	−95	−124	−70	−71	−59	−20	8
3	22	−9	−3	1	−27	27	13	70	73	89	125	142
3	45	−4	35	86	82	172	185	242	251	269	316	346
3	90	−43	37	115	147	257	319	367	370	399	452	481
3	180	−136	−40	53	81	201	301	361	381	431	494	528

[a] Wheat = $0.121/kg ($3.30/bu); N = $0.51/kg ($0.23/lb) first year, NH_3-N = $0.35/kg ($0.16/lb); P = $1.035/kg ($0.47/lb); fertilizer application cost = $6.01/ha ($2.44/A) first year and $10.34/ha ($4.20/A) all other years.
Note: $/ha × 0.405 = $/A.

potentially pay for 50–75% of the fertilizer N added. The average value of the grain protein in each wheat crop of the 90 kg P/ha treatment above that of the check treatment for 0, 45, and 90 kg N/ha treatments was −$1/ha, $12/ha, and $18/ha, respectively.

The results of this study demonstrate that a good balance in available N and P is needed to maximize profits from N and P fertilization and that long-term economic benefits are possible from a single, high-rate fertilizer P application.

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