Yield and Economic Responses to Potassium

Successful farmers know that they must spend money to make money. They look for income-earning inputs that make their farming operations profitable. However, pessimism and negative talk cause some to try to save money by skimping on or omitting income-earning practices. Cutting costs in the wrong place may reduce profits by lowering yields, which makes the unit costs of production higher.

Farmers must reduce their costs per unit of harvested crop in order to optimize profits during times of depressed crop prices. High yields distribute production costs over more bushels or tons, resulting in lower costs per unit of crop production.

Potassium (K) fertilization is one of the vital income-earning inputs that enables farmers to produce crops at lower unit cost. Not only can K boost yields, but it is also one of the least expensive nutrients to buy. Many experiments clearly show the economic benefits of K fertilization for a wide range of soils and cropping conditions in the U.S. and Canada. Several examples have been selected from such studies to illustrate the substantial impact of K on improving earnings.

In this article, the costs considered for K fertilization were soil sample analyses, fertilizer, application, and harvest costs. Soil samples, taken every 2 years, representing 5 acres, and analyzed for phosphorus (P), K and pH, were assumed to cost \$0.75/A/year for chemical analysis. Potassium fertilizer price was set at \$0.14/lb K_2O. Application costs of \$3.00/A, associated with dry bulk applications, were assumed unless otherwise noted. Harvest costs for grain were \$0.17/bu, which included handling (auger, tractor and labor), hauling from field to farmstead, and hauling from farmstead to market. For corn, an additional harvest cost of \$0.18/bu was incurred for drying, assuming harvested corn was dried to 15.5 percent at \$0.022 per percentage point. This brings the fixed costs of K applications (including sampling) to \$3.75/A and the variable harvest costs to \$0.17/bu (grain crops other than corn) or \$0.35/bu (corn). Base costs for crop production footnoted in each table included direct and overhead expenses.

Corn: Table 1 shows how K fertilization in Ohio increased corn yields and profits on a Crosby soil testing low to medium in K. These data demonstrate that applying needed K can

TABLE 1. Potassium fertilization increases corn yields and return per acre by lowering the unit cost of production (Ohio).

K_2O rate, lb/A	Corn grain yield, bu/A	Total yield income, \$/A	Additional harvest costs from yield response to K, \$/A	Additional input costs from K fertilization, \$/A	Total cost per bushel, \$/bu	Net profit, \$/A
0	146	328.50	–	–	2.05	28.50
50	167	375.75	7.35	9.25	1.90	59.15
100	174	391.50	9.80	16.25	1.87	65.45
200	187	420.75	14.35	30.25	1.84	76.15
400	188	423.00	14.70	58.25	1.98	50.05

Base cost without K = \$300/A; soil test K = 126 to 209 lb/A.
Corn = \$2.25/bu; K applied every other year, so amortized application costs were \$1.50/A/yr.

TABLE 2. Deep banded K boosts yields and profitability on a soil testing 314 lb/A K in a ridge-till system (Minnesota).

Deep banded K_2O rate, lb/A	Corn grain yield, bu/A	Total yield income, $/A	Additional harvest costs from yield response to K, $/A	Additional input costs from K fertilization, $/A	Total cost per bushel, $/bu	Net profit, $/A
0	153	344.25	–	–	1.96	44.25
20	162	364.50	3.15	7.55	1.92	53.80
40	162	364.50	3.15	10.35	1.94	51.00
60	159	357.75	2.10	13.15	1.98	42.50
80	165	371.25	4.20	15.95	1.94	51.10

Base cost without K = $300/A; corn sale price = $2.25/bu; band application = $4.00/A.

result in higher yields, which lowers production costs per unit of crop yield.

Tillage and soil management systems can change the need for fertilizer K. In Minnesota, yield responses to K banded below the seed in ridge-till systems have been observed, even on soils testing high in K (**Table 2**). This response is probably related to lower soil K levels within the ridge. Reduced tillage systems can often have stratified levels of soil K that can reduce the availability of K to the crop under adverse conditions. Other factors which can lead to K responses on high K soils include cool, wet conditions, low soil moisture, compaction, low pH, high amounts of calcium (Ca), magnesium (Mg), and/or sodium (Na), and the presence of K-fixing minerals. Also, some soils may simply lack the capacity to supply K fast enough to satisfy crop needs during critical periods of rapid uptake.

Soybeans: Soybeans respond well to K, giving consistent, profitable increases at many locations. The Ohio data in **Table 3** demonstrate the reduction in costs per bushel resulting from K fertilization. Ohio data have also shown the importance of K fertilization in

TABLE 3. Potassium fertilization increases soybean yields and reduces cost per bushel (Ohio).

K_2O rate, lb/A	Soybean yield, bu/A	Total yield income, $/A	Additional harvest costs from yield response to K, $/A	Additional input costs from K fertilization, $/A	Total cost per bushel, $/bu	Net profit, $/A
0	40	250.00	–	–	5.13	45.00
40	43	268.75	0.51	9.35	4.99	53.89
80	45	281.25	0.85	14.95	4.91	60.45
120	48	300.00	1.36	20.55	4.73	73.09

Base cost without K = $205/A; soybean sale price = $6.25/bu.

TABLE 4. Potassium fertilization increases soybean yields and quality on a low K soil in Virginia.

K_2O rate, lb/A	Soybean yield, bu/A	Total yield income, $/A	Moldy beans, %	Dockage for poor soybean quality, $/A	Additional harvest costs from yield response to K, $/A	Additional input costs from K fertilization, $/A	Total cost per bushel, $/bu	Net profit, $/A
0	38	237.50	31	132.24	–	–	8.87	-99.74
120	47	293.75	12	56.40	1.53	20.55	6.03	10.27

Base cost without K = $205/A; soybean sale price = $6.25/bu; dockage for poor soybean quality = $0.12/pt./bu over 2%.

TABLE 5. Adequate K improves spring wheat yield and grain protein content on a low K soil in northeastern Saskatchewan.

K_2O rate, lb/A	Spring wheat yield, bu/A	Total yield income, $/A	Grain protein, %	Additional harvest costs from yield response to K, $/A	Additional input costs from K fertilization, $/A	Total cost per bushel, $/bu	Net profit, $/A
0	34	119.00	13.3	–	–	4.26	-26.00
30	45	157.50	13.8	1.87	7.95	3.44	2.68
60	43	150.50	13.9	1.53	12.15	3.69	-8.17
120	54	189.00	13.9	3.40	20.55	3.13	20.05
240	60	210.00	14.8	4.42	37.35	3.11	23.23
480	63	220.50	15.0	4.93	70.95	3.51	-0.38

Base cost without K = $145/A; spring wheat sale price = $3.50/bu.

adverse conditions, with the greatest soybean yield and profit increases coming from K in dry years. Yield losses incurred from good years to dry years were also cushioned by the use of K.

Substantial improvements in the economics of soybean production occur from the favorable influence of K on quality. This important aspect of K fertilization is readily apparent in **Table 4**.

Small Grains: Although many of the soils in the heart of the Wheat Belt are high in available K, there are some requiring K fertilization for profitable wheat production. For example, yield increases of at least 4 to 10 bu/A resulted from K additions in six states and provinces. Returns on investments from K applications, usually less than 60 lb/A, were 200 percent or higher approximately 60 percent of the time.

On a low K soil in northeastern Saskatchewan, potassium chloride (KCl) fertilization raised spring wheat yields from 34 to 63 bu/A and greatly increased profit (**Table 5**).

No credit was given for higher grain protein in these calculations. When market demands exist for higher protein content, high protein wheat can sell at a premium, providing additional profits.

Applications of KCl on high K testing soils have frequently increased yields of both hard red winter and hard red spring wheat in the Plains states and Prairie Provinces of Canada. These responses are apparently due to K in some situations and to Cl in others.

Responses of barley and wheat to chloride (Cl) fertilization have been extensively studied, and research continues. Chloride is generally beneficial in high disease environments where soil Cl levels are low. A number of diseases in wheat such as the take-all, common and dryland root rots, leaf and stripe rusts, tan spot, and septoria are suppressed by Cl. Response data from more than 200 responsive and non-responsive trials in Kansas, Manitoba, Minnesota, Montana, North Dakota, South Dakota, Saskatchewan, and Texas have been summarized. These data show that for all sites studied, the average yield increase to Cl fertilization was 2.4 bu/A...the average being 5.2 bu/A on responsive sites. Assuming an application of 30 lb Cl/A, this translates to net returns of $2.34/A and $11.67/A for all sites and responsive sites only, respectively.

Cotton: Potassium is essential for maximizing the profitability of cotton production. **Table 6** shows a cotton yield response to broadcast applications of K. Costs considered for K fertilization were those assumed earlier in this article ($0.14/lb K_2O and fixed input costs of $3.75/A). Using K also improved cotton lint quality properties including micronaire and fiber length and elongation (see page 28).

Foliar applications of K on cotton can be profitable for fast-fruiting cultivars grown on soils low in K. A study in Tennessee showed that foliar applications of K were profitable for at least two years, even when relatively high rates of K were soil-applied each year. In this study, K was soil-applied at rates from zero to 120 lb K_2O/A. In addition, 40 lb/A of potassium nitrate (KNO_3) was foliar applied in 10 lb/A increments on a 9 to 14 day interval starting at or shortly after bloom. The KNO_3 was $0.26/lb, and the foliar application costs were about $9/A. A recent 10-year average Tennessee cotton price of $0.584/lb was used. Net revenue gain from foliar fertilization (**Table 7**) was calculated by subtracting the product and application costs from the additional revenue gained from cotton yield responses.

TABLE 6. Fertilizer K boosts cotton yields (Mississippi).

K_2O rate, lb/A	Lint yield, lb/A	K input costs, $/A	Return to K, $/A
0	1,061	–	–
120	1,169	20.55	42.52

Cotton price = $0.584/lb.

TABLE 7. Economic responses of cotton to foliar applications of K (Tennessee).

Initial soil test K level, ppm[1]	Tillage	Year	Net revenue gained from foliar application of KNO_3, $/A, at various rates of soil applied K, lb K_2O/A: 0	30	60	90	120
45	Conventional	1	-3	27	41	39	21
		2	21	18	14	8	2
		3	15	13	3	-14	-39
		4	40	76	82	58	6
40	No-till	1	16	35	46	49	43
		2	46	27	18	20	33
		3	66	31	7	-6	-9
		4	123	66	20	-14	-36

[1]ppm = parts per million.

Alfalfa: High-yielding alfalfa removes large amounts of K from the soil, usually from 50 to 75 lb of K_2O/ton of dry matter. Most farmers don't apply enough K for their alfalfa, losing yields and profits while draining soil K supplies. The profitability of K fertilization, as in other crops, depends in part on soil test K levels.

TABLE 8. Potassium recommendations and net returns change with soil test levels.

Soil test K	Optimum K rate, lb K_2O/A	K input costs, $/A	Yield response, ton/A	Net return to K, $/A
Very low	335	50.65	1.2	57.35
Low	260	40.15	1.0	49.85
High	90	16.35	0.2	1.65

Hay price = $90/ton.

Normally, less K is required on soils with higher K levels. Some examples of using K at the most economic rate are shown in **Table 8**. Data for **Table 8** came from Wisconsin, New York and Pennsylvania. At lower soil K levels, more K is needed to maximize profitability.

Summary

The most profitable farm operations are not the ones that have the lowest operational costs. Instead, wise investments are the key to financial success. Applications of K can be very profitable when K is in short supply. In such cases, increased returns are achieved only through increased investments. Identifying situations where K is limiting and investing in K fertilizer inputs is a practice that can substantially boost profits. BC