Profitability of . . .
Fertilizing Wheat
in Umatilla County

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Rising costs and lower prices have farmers in the well-known "price-cost" squeeze. Farmers now must think twice before spending for fertilizers, chemicals, or other products that may or may not increase yields the coming year.

Farmers have known for a long time that nitrogen will increase yields under favorable conditions. Use of elemental nitrogen in Oregon jumped from 1,077 tons in 1939 to 25,640 tons in 1953.

Research results at the Pendleton branch experiment station have shown to what extent nitrogen can increase wheat yields. But when it comes to deciding which rate of application will return the most, there is still considerable guesswork.

The following economic analysis can remove some of the guesswork if rainfall, soil, and climate at your farm are similar to that of the Pendleton station.

Continuous Winter Wheat

Results of fertilizing continuous winter wheat for a 7-year period are grouped in figure 1. These trends in yields were taken from experiments conducted on the same plots in successive years of continuous cropping. Thus, results should be similar to farm conditions where fertilizer may be applied year after year.

Wheat yields were increased by nitrogen in all years except 1949. In contrast to poor results in 1949, yields in 1946 were greatly increased by nitrogen, producing over 50 bushels per acre at 90 and 120 pounds of elemental nitrogen.

Because of the yield variation shown in figure 1, there is apparently a considerable "gamble" involved in applying nitrogen to wheat. Yet average results over the seven years show a marked response to nitrogen.

According to the "average" line in figure 1, 90 pounds of nitrogen would increase yields about 13 bushels per acre; 60 pounds of nitrogen, about 11 bushels. Which rate would "pay" or return the most?

To find the answer, wheat prices and fertilizer costs have to be considered. Let's assume that wheat is worth $2 per bushel, less 25 cents per bushel harvesting cost, while nitrogen costs 12 cents a pound.

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Figure I. Estimated average wheat yields for continuous winter wheat.

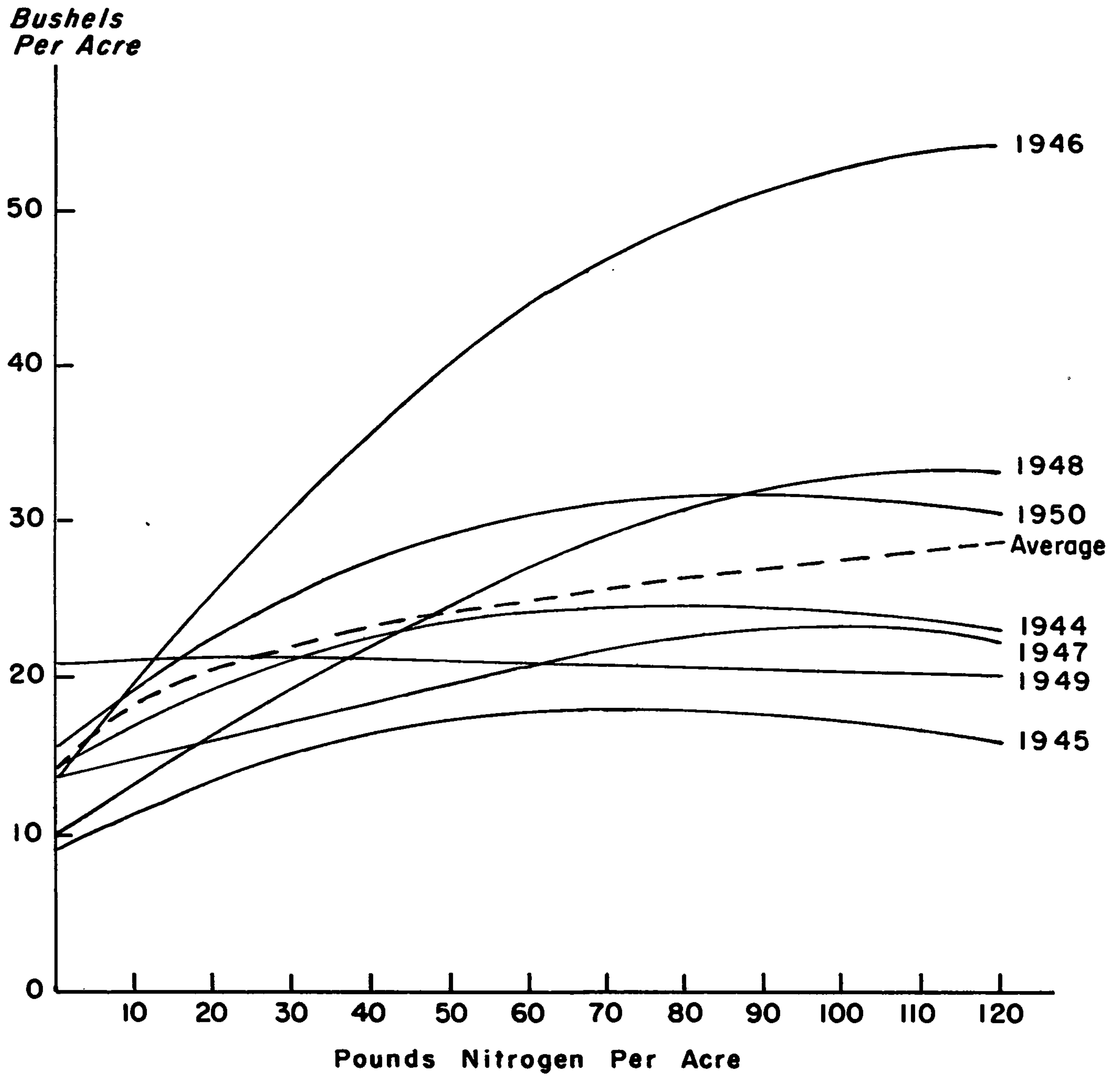


Figure 2 shows the most profitable rate for these prices--the 80-pound rate. The curve shows profits left after nitrogen costs are subtracted from the value of increased wheat yields.

Increased profits over nitrogen costs are also given in table 1. Although the 80-pound rate gave the greatest margin per acre, $10.97, any of the rates from 40 to 100 pounds were almost as good, returning $10 or more per acre.

Gross returns from each dollar spent for nitrogen are shown in figure 3. Returns decrease for each 10 pounds of nitrogen added. This decreased return per dollar spent is important for those short on cash, or for tenants.

With tenants who pay all fertilizer costs but receive only two-thirds of the benefit, lower nitrogen rates will "pay" more than higher rates. In such a case the tenant would profit more

Figure 2. Estimated increased profits from nitrogen applications to continuous winter wheat.

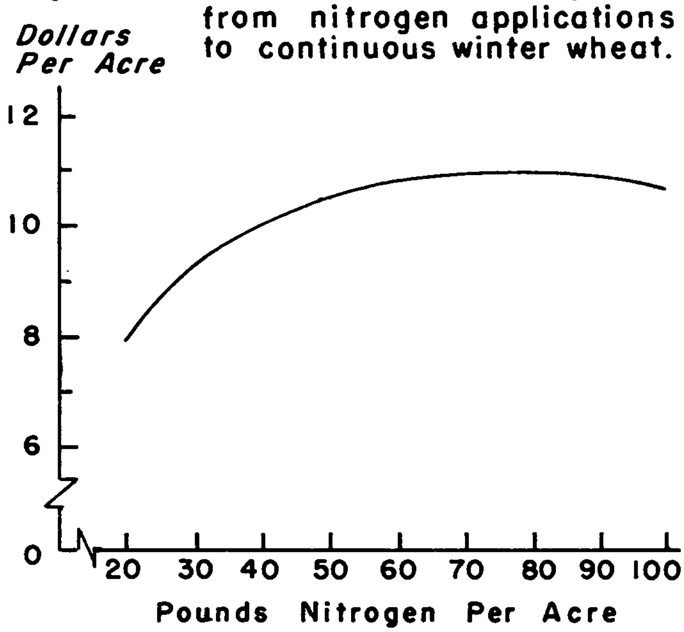


Figure 3. Estimated gross returns per nitrogen dollar, continuous winter wheat.

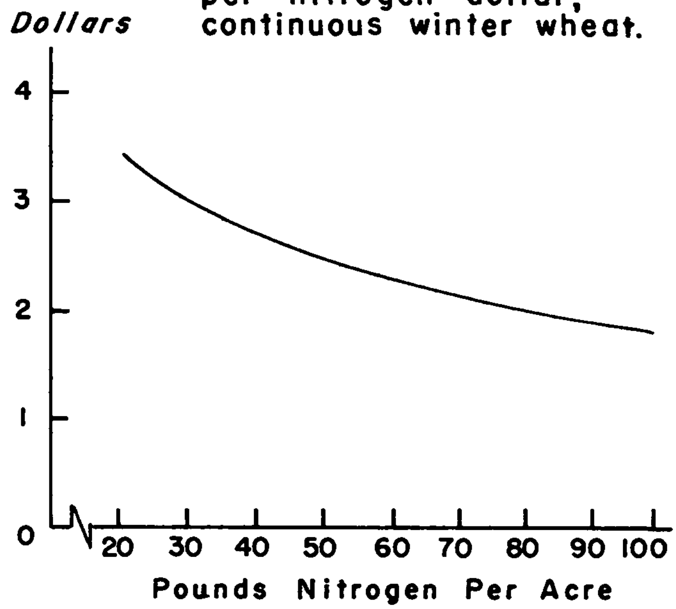


Table 1. Predicted Increases in Yield of Continuous Winter Wheat and Returns at Various Rates of Nitrogen

Nitrogen applied	Predicted increase in yield from nitrogen application	Value of increased yield /a	Cost of nitrogen/b	Margin of increased value of wheat crop over cost of nitrogen/a	Gross return per dollar spent on nitrogen
Pounds	Bu. per acre				
20	6.48	$11.34	$3.30	$8.04	$3.44
30	7.85	13.74	4.50	9.24	3.05
40	8.97	15.70	5.70	10.00	2.75
50	9.93	17.38	6.90	10.48	2.52
60	10.79	18.88	8.10	10.78	2.33
70	11.56	20.23	9.30	10.93	2.18
80	12.27	21.47	10.50	10.97	2.04
90	12.93	22.63	11.70	10.93	1.93
100	13.54	23.70	12.90	10.80	1.84

/a Increased yield was valued at $1.75 per bushel which was $2.00 per bushel minus $0.25 for extra harvesting costs.

/b Estimated to be $0.90 per acre for machine hire, tractor expense, and labor plus $0.12 per pound of nitrogen.

by cutting back to 40 pounds per acre at prices assumed in table 1. The tenant's share of the increased wheat yield would be two-thirds of the 8.97 bushels or about 6 bushels per acre. Multiplying 6 by $1.75 gives a value to the tenant of about $10.50. His margin per acre over cost of fertilizer would be $10.50 - $5.70 = $4.80. Other rates in table 1 would give the tenant in this case a smaller margin per acre.

Most profitable nitrogen rates can also be determined when nitrogen or wheat prices change. All you do is divide nitrogen cost per pound by wheat price per bushel minus harvesting costs.

Below are listed the ratios pegged to the 7-year yield average for various nitrogen rates at the Pendleton station:

Nitrogen rate Pounds/acre	Ratio
20	.15
30	.12
40	.10
50	.09
60	.08
70	.074
80	.068
90	.063
100	.059

With these ratios, you can predict which nitrogen rates will give highest returns. For example, assume the wheat price decreases to $1.25 a bushel, harvesting costs remain the same--25 cents per bushel, and nitrogen costs 12 cents per pound. Dividing the cost of nitrogen per pound by the net wheat price gives $0.12/$1.00 = .12. For a ratio of .12, the 30-pound nitrogen rate is indicated.

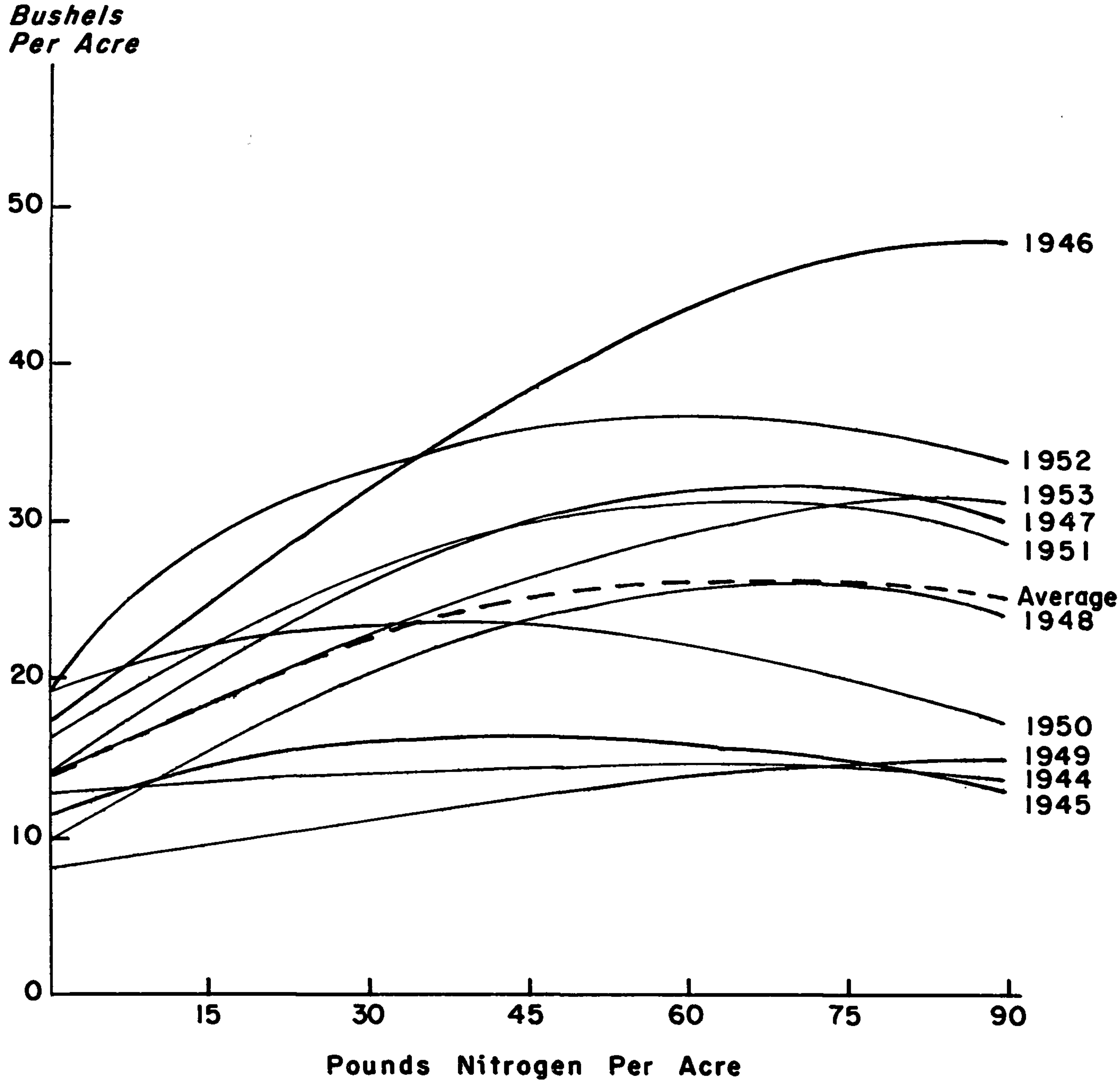
Again, available cash and type of tenancy agreement are important. Tenants can use the ratios by figuring their share of the wheat price. For example, if wheat were $2.10 per bushel, the tenant's share of the value of increased yield from fertilizer would usually be two-thirds times $2.10 or $1.40 per bushel./1 If harvesting the extra wheat from fertilizer costs an additional 20 cents per bushel, the tenant would realize $1.20 for each increased bushel from fertilizer. Using the ratio, $.12/$1.20 = .10, the 40-pound rate is indicated.

Continuous Spring Wheat

Patterns of continuous spring wheat yields over a 10-year period are shown in figure 4. Increased yields from nitrogen follow a pattern similar to that of continuous winter wheat. Over the 10-year period, 30 pounds of nitrogen increased yield an average of approximately eight bushels over the nonfertilized plots. About four additional bushels over the 30-pound rate resulted from the 60-pound application of nitrogen. At 90 pounds, average yields decreased one bushel from the yield at 60 pounds of nitrogen.

/1 Where tenant and landlord share the cost of fertilizer according to their share of the crop, the most profitable rate for the tenant would be the same as for an owner-operator.

Figure 4. Estimated average wheat yields for continuous spring wheat.



To determine which rate would be most profitable, the price of wheat and cost of nitrogen must be considered as well as increased yield. If wheat is worth $2 per bushel and nitrogen costs 12 cents a pound, figures in table 2 can be used. The margin over cost of nitrogen is greatest at 60 pounds of nitrogen, being over $13 per acre. The answer can also be seen graphically in figure 5 where increased profits from fertilizing wheat are greatest at the 60-pound rate.

Table 2. Predicted Increases in Yield of Continuous Spring Wheat and Returns at Various Rates of Nitrogen

Nitrogen applied	Predicted increase in yield from nitrogen application	Value of increased yield /a	Cost of nitrogen /b	Margin of increased value of wheat crop over cost of nitrogen /a	Gross return per dollar spent on nitrogen
Pounds	Bu. per acre				
20	6.06	$10.61	$ 3.30	$ 7.31	$3.22
30	8.32	14.56	4.50	10.06	3.24
40	10.09	17.66	5.70	11.96	3.10
50	11.37	19.90	6.90	13.00	2.88
60	12.15	21.26	8.10	13.16	2.62
70	12.42	21.74	9.30	12.44	2.34
80	12.21	21.37	10.50	10.87	2.04
90	11.49	20.11	11.70	8.41	1.72

/a Increased yield was valued at $1.75 per bushel which was $2.00 per bushel minus $0.25 for extra harvesting costs incurred.

/b Estimated to be $0.90 per acre for machine hire, tractor expense, and labor plus $0.12 per pound of nitrogen.

Gross returns from each dollar spent for nitrogen in figure 6 must also be considered by those short on cash. Since the return decreases with each added amount of nitrogen past the 30-pound rate, farmers get the greatest return per dollar spent at the lower rates. For example, if a farmer had just enough money to apply either 30 pounds of nitrogen on his entire 400 acres of wheat or 60 pounds on half of it, 200 acres, it would usually pay him to apply the lighter rate on the entire acreage. At the 30-pound rate, yield would be increased 8.32 bushels times 400 acres for a total increase of about 3,328 bushels. If 60 pounds were applied on only 200 acres, the increased yield would be only about 2,430 bushels or almost 900 bushels less. Therefore, the individual farmer's capital position must be considered in choosing an "optimum" rate.

Although nitrogen or wheat prices may change, the most profitable nitrogen rate can still be figured. All you do is divide nitrogen cost per pound by wheat price per bushel minus harvesting costs. This ratio can then be compared to the following ratios calculated from the 10-year yields for various nitrogen rates at the Pendleton station:

Nitrogen rate Pounds/acre	Ratio
20	.25
30	.20
40	.15
50	.10
60	.05
70	.003

With these ratios, you can predict which nitrogen rate will return the greatest margin per acre over nitrogen cost. For example, if wheat falls to $1.50 per bushel, harvesting costs remain at 25 cents per bushel, and nitrogen costs $.12 per pound, the appropriate ratio is $.12/$1.25 = .96. Therefore, the 50-pound rate is selected (50 pounds is .10, the nearest to

Figure 5. Estimated increased profits from nitrogen applications to continuous spring wheat.

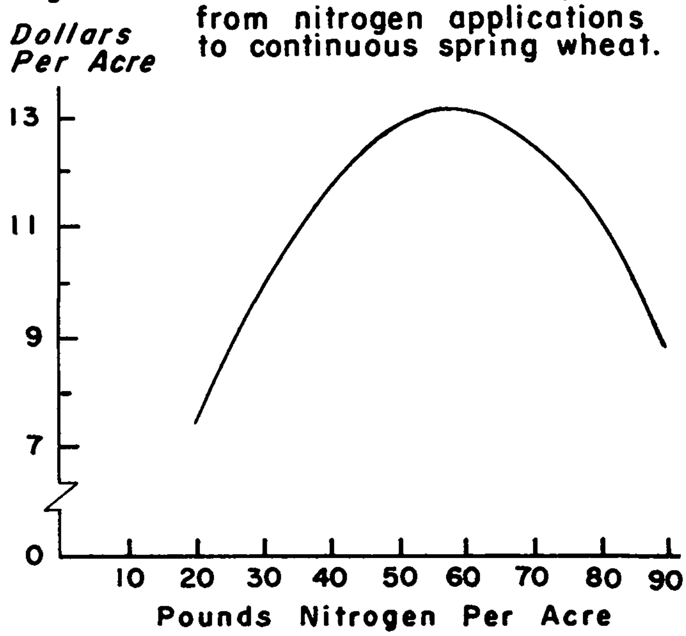
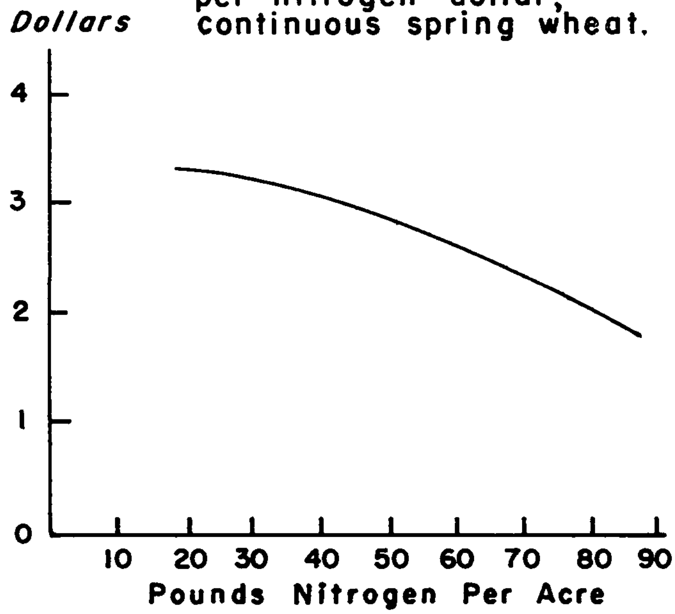


Figure 6. Estimated gross returns per nitrogen dollar, continuous spring wheat.



.96). Again, available cash and the type of tenancy arrangement would have to be considered.

For a tenant in the preceding price situation who paid all fertilizer costs and received two-thirds of the crop, the appropriate wheat price would be 2/3 x $1.50 = $1.00. Then, $1.00 minus 25 cents extra harvesting cost would give a ratio of $.12/$.75 = .16. The 40-pound rate would be selected since the ratio for the 40-pound rate is .15, the nearest to .16.

Winter Wheat After Fallow

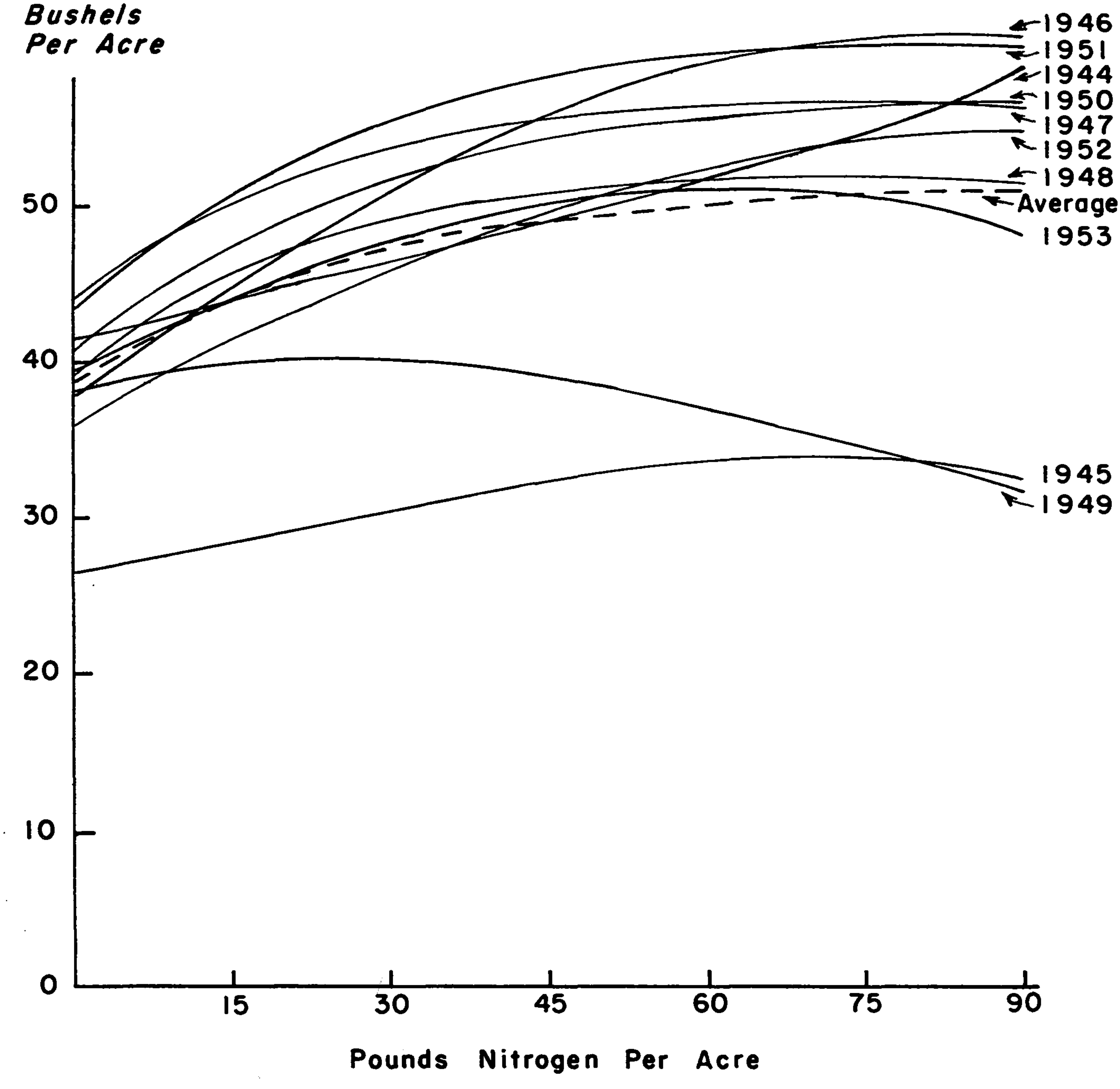
Response of winter wheat to nitrogen after fallow is shown in figure 7. The experiments were conducted over a 10-year period, 1944 to 1953. An average increase in yield of over eight bushels per acre was recorded for the 30-pound application. (The average yield increase per acre for continuous spring wheat and continuous winter wheat was also about eight bushels.) The 60-pound application of nitrogen on winter wheat after fallow gave an additional increase of about three bushels per acre over the 30-pound rate, while 90 pounds produced an additional bushel over the 60-pound rate.

Let's consider wheat prices of $2.00 per bushel minus 25 cents per bushel harvesting costs and nitrogen costs of 12 cents a pound. Which rate would "pay" or return the most?

Figure 8 shows the answer -- the 60-pound rate. The curve shows profits left after nitrogen costs are subtracted from the value of increased wheat yields. In table 3, these margins over cost of nitrogen are also presented. Margins of around $11 per acre are predicted, on the average, for application rates of 40 to 80 pounds.

Since margins are about the same for a wide range of rates, farmers have considerable choice in selecting rates. Gross returns per dollar spent on nitrogen becomes important, especially for those short on cash.

Figure 7. Estimated average wheat yields for winter wheat after fallow.



Gross returns per dollar spent on nitrogen decline from $3.36 at the 30-pound rate to the $2.43 at 60 pounds. This decline occurs because the increased value of the wheat crop over the cost of nitrogen was $11.55 at 60 pounds compared to $10.62 at 30 pounds; net profits from nitrogen were increased only $0.93 in going from the 30-pound to the 60-pound rate. On the other hand, total expenditure for fertilizer was increased from $4.50 to $8.10, or $3.60 per acre. Thus, the second 30 pounds of nitrogen costs $3.60 and makes a gross return of only $4.53. Consequently, gross returns per dollar spent on nitrogen decline at the higher rates.

Figure 8. Estimated increased profits from nitrogen application to winter wheat after fallow.

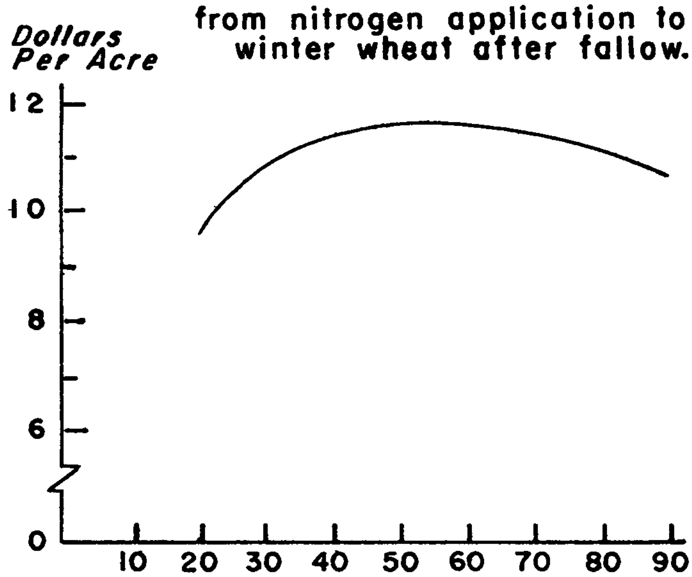


Figure 9. Estimated gross returns per nitrogen dollar, winter wheat after fallow.

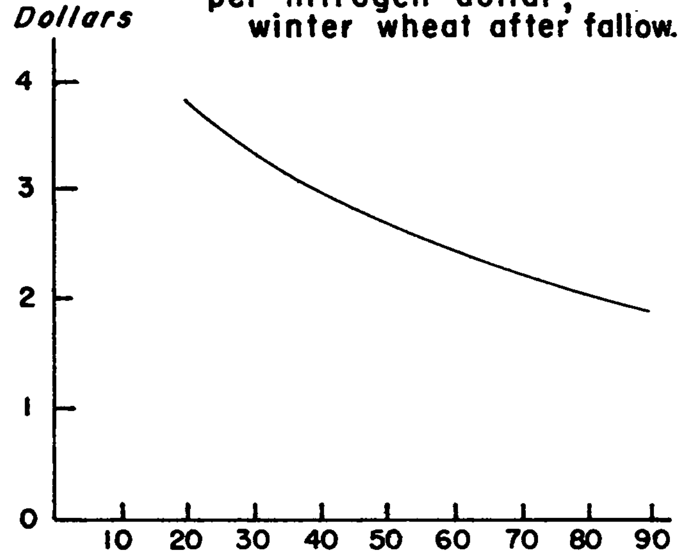


Table 3. Predicted Increases in Yield of Winter Wheat After Fallow and Returns at Various Rates of Nitrogen

Nitrogen applied	Predicted increase in yield from nitrogen application	Value of increased yield /a	Cost of nitrogen /b	Margin of increased value of wheat crop over cost of nitrogen /a	Gross return per dollar spent on nitrogen
Pounds	Bu. per acre				
20	7.31	$12.79	$ 3.30	$ 9.49	$3.88
30	8.64	15.12	4.50	10.62	3.36
40	9.67	16.92	5.70	11.22	2.97
50	10.52	18.41	6.90	11.51	2.67
60	11.23	19.65	8.10	11.55	2.43
70	11.83	20.70	9.30	11.50	2.23
80	12.36	21.63	10.50	11.13	2.06
90	12.82	22.44	11.70	10.74	1.92

/a Increased yield was valued at $1.75 per bushel which was $2.00 per bushel minus $0.25 for extra harvesting costs incurred.

/b Estimated to be $0.90 per acre for machine hire, tractor expense, and labor plus $0.12 per pound of nitrogen.

Because of diminishing returns at the higher rates, farmers may be "trading dollars" with the money invested in nitrogen in excess of 40-50 pounds per acre. However, in unusually favorable years, higher rates can be very profitable.

Profit margins in figure 8 and table 3 are based on wheat prices of $2.00 per bushel and $.12 per pound for nitrogen. With changes in price, returns from nitrogen also change. However, a series of nitrogen-wheat price ratios have been computed which can be used for almost any nitrogen-wheat price situation.

Below are listed the ratios pegged to the 10-year average yield response to nitrogen at the Pendleton station:

Nitrogen rates Pounds/acre	Ratio
20	.15
30	.12
40	.093
50	.077
60	.065
70	.056
80	.049
90	.043

With these ratios, you can predict which nitrogen rate will return the greatest margin per acre over fertilizer cost. For example, let's say wheat prices increase to $2.60 a bushel, harvesting costs remain the same - 25 cents per bushel, and nitrogen costs 12 cents a pound. Dividing the cost of nitrogen by the wheat price minus harvesting cost gives a ratio of $.12/$2.35 = .051, or the 80-pound rate (80 pounds is .049, the nearest to .051). Again, available cash and type of tenancy agreement are important.

If the tenant had the same prices but paid all fertilizer cost and received only two-thirds of the crops, it would pay him to fertilize--but at a reduced rate. For example, the effective wheat price to the tenant would be 2/3 x $2.60 = $1.73. Subtracting harvesting costs of 25 cents per bushel would give a ratio of $.12/$1.48 = .081. According to this ratio, he should apply 50 pounds of nitrogen, or slightly less, per acre. According to table 3, he could expect an average increase in yield of around 10.5 bushels. Two-thirds of this expected increase would give the tenant an average of about seven bushels per acre, which would be worth over $16 per acre to him after subtracting harvesting costs. Cost of fertilizer would be around $8, leaving a margin over cost to the tenant of $8. Of course, with lower prices of wheat, shortage of money, or unfavorable growing conditions it might not "pay" to apply any nitrogen. For example, yields in 1949 appeared to be depressed by nitrogen in figure 7.

Continuous Wheat Vs.Wheat After Fallow

Fertilizer-yield relationships can also be used to help decide which crop to grow. By estimating cash costs associated with each crop, net returns for each crop under given price conditions can be computed. In table 4, winter wheat after fallow, continuous winter wheat, and continuous spring wheat are compared. Predicted yields in table 4 were estimated from the same experimental yields upon which the preceding sections were based.

Table 4. Returns Over Costs for Winter Wheat After Fallow, Continuous Winter Wheat, and Continuous Spring Wheat Without Fertilizer and at Optimum Fertilizer Rates

Crop	Without application of nitrogen				
	Predicted harvested yield	Annual yield	Annual value of crop per acre	Average cash cost per acre	Annual margin per acre over costs
	Bushels	Bushels			
Winter wheat after fallow	38.38	19.19	$38.38	$10.02	$28.36
Continuous winter wheat	13.99	13.99	$27.98	$13.40	$14.58
Continuous spring wheat	13.99	13.99	$27.98	$13.40	$14.58

Crop	With optimum rates of nitrogen					
	Nitrogen per acre	Predicted harvested yield	Annual yield	Annual value of crop per acre	Average cash cost per acre/a	Margin over costs
	Pounds	Bushels	Bushels			
Winter wheat after fallow	60	49.61	24.80	$49.61	$15.19	$34.42
Continuous winter wheat	80	26.26	26.26	$52.52	$26.35	$26.17
Continuous spring wheat	60	26.14	26.14	$52.28	$23.93	$28.35

/a Same as without fertilizer except for $0.20 harvesting costs per bushel of increased yield and $0.90 per acre plus $0.12 per pound for fertilizer costs.

When there was no nitrogen applied, winter wheat after fallow had a distinct advantage over both continuous spring and continuous winter wheat. In fact, five bushels of wheat more could be had from an acre, on the average, from winter wheat after fallow than from the same acre planted to continuous wheat. Furthermore, the greater production from wheat after fallow could be obtained at a lower cost. Because of lower production per acre and higher costs for the continuous wheat, the estimated annual average margin for continuous wheat was less than $15 per acre as compared to about $28 per acre for winter wheat after fallow.

In the lower half of table 4 the yields per acre for continuous spring and winter wheat have been compared with winter wheat after fallow at optimum levels of fertilization for both crops. With the application of nitrogen the continuous wheat compares more favorably; somewhat more wheat can be grown on one acre from continuous wheat than from wheat after fallow. However, this higher average annual yield is produced at a definitely higher machine and fertilizer cost since the annual crop must be planted, fertilized, and harvested every year. Due to the lower average annual cost per acre winter wheat after fallow returned an annual margin per acre over costs of $6 to $8 more than the continuous spring and winter wheat.

Comparison of continuous winter wheat with continuous spring wheat and with winter wheat after fallow in table 4 may not be entirely fair since continuous winter wheat ran only 7 years, 1944 to 1950, as compared to 10 years, 1944 to 1953, for the others. However, results in table 4 are consistent with other experimental results comparing winter and spring wheat at the Pendleton station.

If there were no acreage restrictions, it is possible that farmers might be able to decide on the basis of moisture conditions whether to put wheat after fallow or to plant continuous wheat. For example, continuous spring and winter wheat gave 40 to 50 bushels yield at high rates of nitrogen in 1946. However, if the farmer cannot predict the occurrence of the favorable years, wheat after fallow with applied nitrogen would be the most profitable wheat cropping sequence. Of course, this conclusion would apply only to farms with soil and precipitation conditions similar to that of the Pendleton Branch Experiment Station.

Limitations

Two important limitations to widespread use of the preceding figures are discussed below.

They are based on average results over 7 and 10 years. Yield responses varied greatly in figures 2, 5, and 8. Will next year be a "good" one like 1946? Or a "poor" one like 1949? Good judgment and some guessing will be needed. About 40% of the yield variation is due to nitrogen. Sixty per cent of the variation is due to unexplained causes, such as differences in available moisture and climate from year to year.

Average yields at the Pendleton station may differ from those at your farm. Yearly precipitation averaged 16.7 inches at the Pendleton Station during the 10-year period of the experiments, 1944-1953. Soils are Walla Walla silt loam. Results apply most directly to farms with similar soil, rainfall, and climate.