

Effects of Fertilizer Cutbacks

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Fertilizers are used to supply nutrients that crops need, and the soil cannot supply adequately. Most forms of agriculture are quite reliant on fertilizers to replace nutrients removed with grains. This is particularly important where agriculture has been practiced for a long time, and nutrients have been extensively depleted from the soil. Other yield enhancing technologies like improved cultivars, better pest management, and improved cultural practices make fertilizers even more important to ensure that higher yield potentials are realized.

For any nutrient, the optimal amount is determined by

- the capacity of the soil to supply that nutrient [soil fertility]
- quantities of other nutrients present [nutrient balances]
- the ability of the crop to use that nutrient [yield potential]
- growing season conditions [climate]
- economic conditions

Soil testing and previous experience are used to provide an estimate of the ability of the soil to supply nutrients, and of yield potential. Yield potential and consequently crop use is often limited by the supply of moisture under our conditions, but other factors are also important. These include the length of the growing season, soil conditions, pests, other nutrient levels and management factors like seeding time, seed quality, plant spacing etc.

Thus fertilizer strategy becomes one of matching the supply of nutrients from all sources with the yield potential of the crop grown in that field, and then scaling the rate back to an economic optimum level.

Fertilizers are a significant component of the cost of producing a crop, accounting for about 25% of variable expenses, or 15% of variable plus fixed expenses for crops grown on stubble. Because this component is large, it is often targeted for cuts when economic or climatic conditions are unfavorable. Typical situations where fertilizer cutbacks are considered include:

- when yields are expected to be low [drought]
- when grain prices are very low
- when fertilizer prices are high
- when input \$s are tight
- when economic uncertainty is high

Cuts are usually made to fertilizer N, despite this being the nutrient that provides the most consistent yield response. To understand the implications of N cutbacks, and develop strategies that do not result in large losses requires a good understanding of crop response to N and how economics are affected.

Figure 1 provides a schematic illustration of how wheat responds to N under various levels of moisture stress. When moisture stress is high, relatively little N is needed to utilize available moisture. Under dry conditions, most if not all of the N requirement, can be met from the soil.

Consequently, less fertilizer N is needed. The appropriate reduction in fertilizer N may be proportionally much larger than the yield reduction. Conversely, under very favorable moisture, wheat will continue to respond to very high levels of N. Under such conditions, most of the N required would normally be supplied as fertilizer.

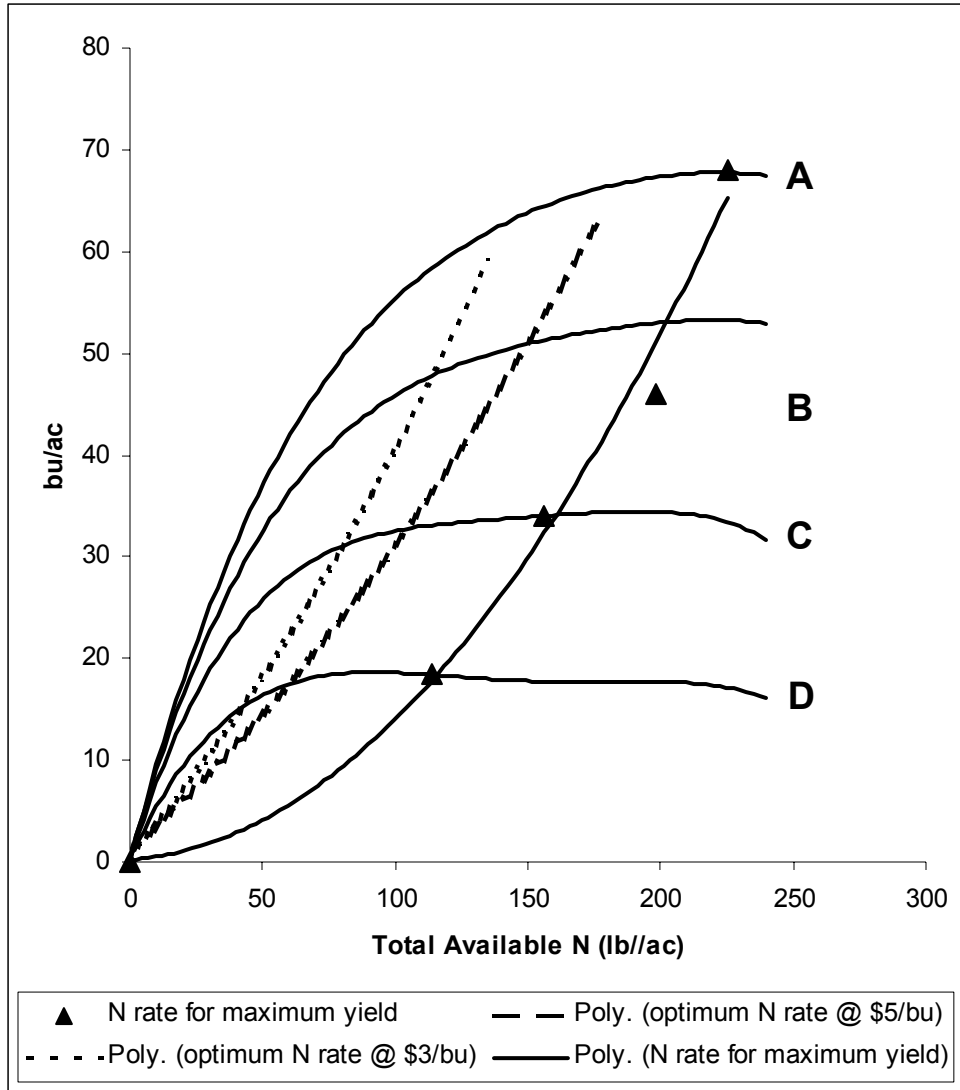


Figure 1. Influence of moisture stress [A= low, to, D= high stress] on yield response by wheat to varying amounts of total nitrogen.

Applying economics provides insight into the impact of wheat prices on the optimum level of N. In this example, it is assumed that all N was supplied as fertilizer. In practice, somewhere between 10 and 75 lb/ac would be supplied from the soil. Where wheat prices are low [\$3/bu], the optimal amount of N is consistently lower than where wheat prices are higher [\$5/bu]. At either price, the optimum is lower than the maximum yield achievable. Overall, wheat prices tend to have a much smaller impact on the optimal level of N than does moisture stress. What this means is that moisture conditions should have a greater impact on N rates than commodity prices.

Somewhat similar responses have been noted for canola [Figure 2]. During 2000, moisture was 5 to 20% above normal at the 3 locations, and canola continued to respond to high rates of N. Yield was not maximized even at the 135 lb/ac rate. With growing season precipitation that was 40 to 60 % below normal in 2001, yield was much lower and reached a maximum at less than 100 lb/ac of N.

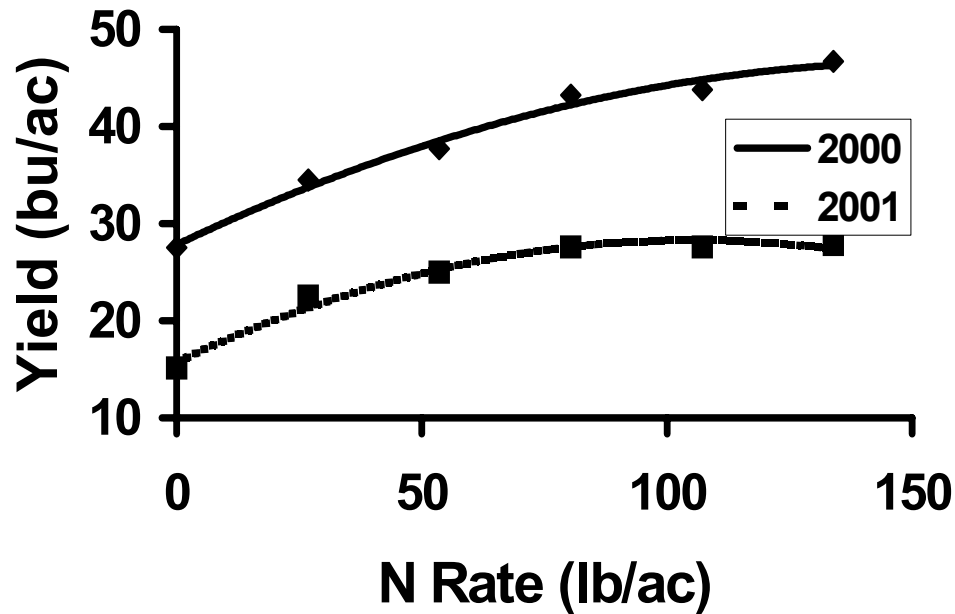


Figure 2. Canola yield response to N fertility with above [2000] and below [2001] normal moisture. [Averages for Melfort, Indian Head and Scott].

The economic optimum N rate was also much higher under more favorable moisture in 2000 [Figure 3]. Again it had not reached its maximum at the maximum N rate of 135 lb/ac. By contrast, in 2001, the economic optimum was reached at about 75 lb/ac of N. Obviously the supply of moisture has a very large influence on the optimum rate of N.

The price of canola had a large influence on net returns, but had only a minor impact on the optimum N rate [Figure 4]. Based on N responses averaged across locations and years, the optimum N rate declined from about 105 lb/ac at \$10/bu to about 90 lb/ac when canola was at \$6/bu.

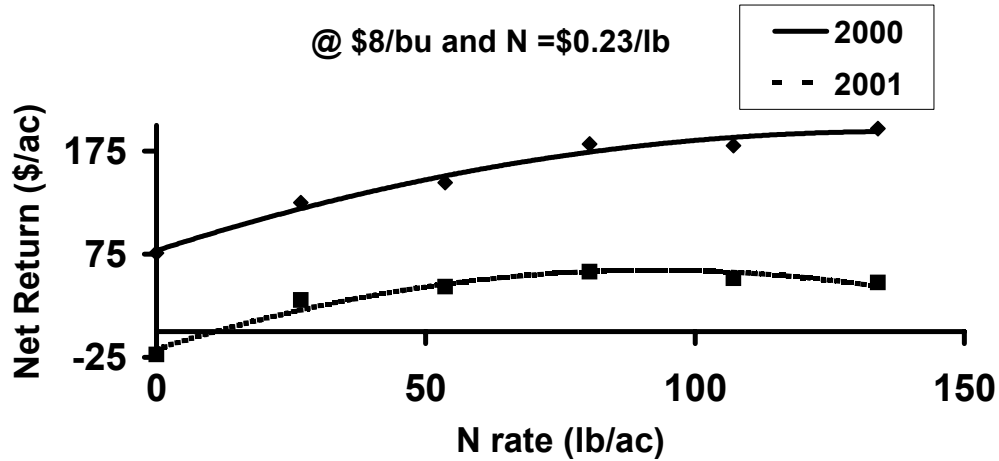


Figure 3. Canola net returns in response to N fertility with above [2000] and below [2001] normal moisture. [Averages for Melfort, Indian Head and Scott].

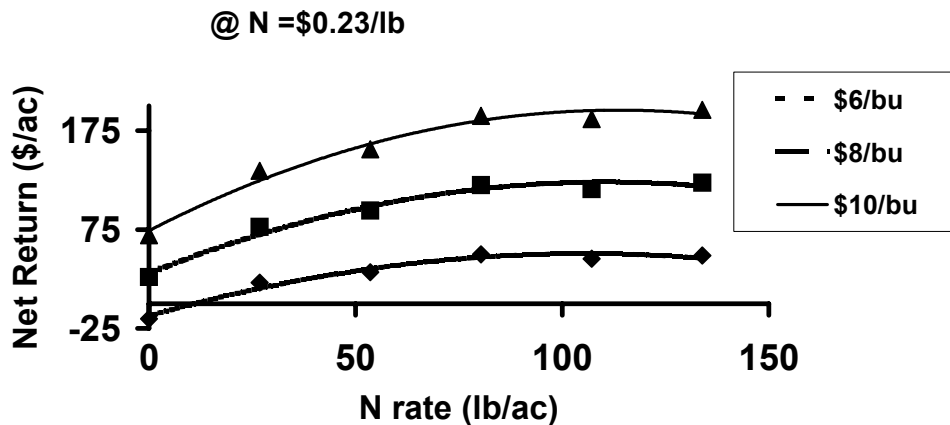


Figure 4. Canola net returns in response to N fertility with canola priced at 6, 8 and 10 dollars per bushel. [Averages for Melfort, Indian Head and Scott during 2000 and 2001].

The impact of the cost of fertilizer N on optimum N rates was dependent upon the price of canola [Figure 5]. At high canola prices, the price of N had very little impact on the optimum N rate. At very low canola prices, the impact of N cost was greater, but the difference in the optimum N rate was still small compared with the influence of moisture on optimum N rates.

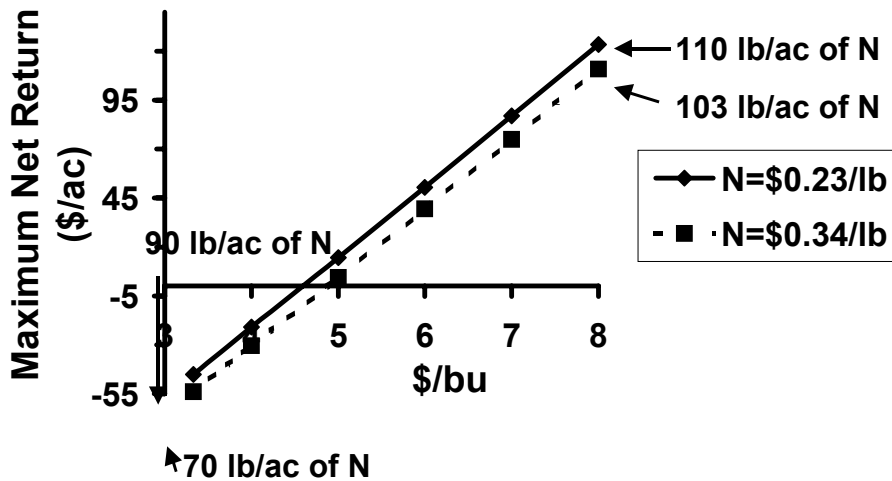


Figure 5. Canola net returns as influenced by fertilizer N costs with canola priced at 3 to 8 dollars per bushel. [Averages for Melfort, Indian Head and Scott during 2000 and 2001].

Overall, the supply of moisture has the greatest influence on appropriate N rates. Prices for grains and fertilizer have relatively smaller effects. Thus decisions regarding suitable application rates need to consider what is a realistic yield potential for the upcoming crop.

A useful tool has been developed to estimate yield of some crops based on moisture conditions and other soil climatic factors associated with the major soil zones of Saskatchewan [Table 1]. The equations for calculating yield use a factor for the supply of water [WU] minus the amount of water consumed before any yield is produced. The difference is multiplied by a factor that represents an estimate of the bushels of grain produced per inch of water available.

Table 1. Yield equations for wheat, barley and canola by soil zone.

Soil Zone	CWRS Wheat	Barley	Canola
Dry Brown	$Y=(WU-2.5) \times 3.5$	$Y=(WU-2.5) \times 5.3$	$Y=(WU-2.5) \times 2.0$
Brown	$Y=(WU-2.25) \times 3.75$	$Y=(WU-2.25) \times 5.7$	$Y=(WU-2.25) \times 2.5$
Dark Brown	$Y=(WU-2.0) \times 4.0$	$Y=(WU-2.0) \times 6.0$	$Y=(WU-2.0) \times 3.0$
Thin Black	$Y=(WU-1.75) \times 4.25$	$Y=(WU-1.75) \times 6.4$	$Y=(WU-1.75) \times 3.3$
Thick/Gray Black	$Y=(WU-1.5) \times 4.5$	$Y=(WU-1.5) \times 6.7$	$Y=(WU-1.5) \times 3.6$
Gray	$Y=(WU-1.25) \times 4.75$	$Y=(WU-1.25) \times 7.2$	$Y=(WU-1.25) \times 4.0$

Y= yield in bu/ac; WU= water use; inches of stored spring soil water plus growing season [May-July] precipitation. Source: "Criteria for Targeting Yields in Saskatchewan" Soils and Crops Workshop, 1991. R.E. Karamanos and J.L. Henry, Dept of Soil Science, University of Saskatchewan, as adapted by Saskatchewan Agriculture and Food on their website.

It is notable that the amount of water consumed before any yield is produced is higher and the yield per unit of water is lower as one moves from typically drier [Brown] to wetter [Gray] regions. Thus water use efficiency is lower in those regions that are typically drier.

Similarly, spring soil moisture on stubble, and precipitation is usually higher for the Black and Gray than for the Brown and Dark Brown soil zones [Table 2]. We tend to be well aware that precipitation can be highly variable from year to year across the region, but the same applies to

stubble soil moisture. Because both soil moisture and growing season precipitation are so highly variable, the supply of moisture for crop production and thus yield potential is similarly variable.

Typically the supply of moisture is lowest and most variable for the Brown soil zone. The gray soil zone has a higher and more consistent supply of moisture, with conditions that are intermediate for the Dark Brown and Black zones. However, drought does occur in all soil zones.

Growing season rain cannot be reliably predicted, however soil moisture at seeding can be measured. Where fertilizer cutbacks are being considered, soil moisture at seeding can be used as a guideline. If moisture is below normal, a reduction may be warranted, but where it is above normal, yield is more likely to be reduced by nutrient deficiencies than by moisture.

Table 2. Typical stubble spring soil moisture and accumulated precipitation from May 1 to July 31 and typical ranges for each across soil zones of Saskatchewan. [Adapted from various published reports of soil moisture and selected Environment Canada weather recording sites].

	Soil Zone			
	Brown	D. Brown	Black	Gray
Stubble soil moisture in spring				
-average	2.75	3.25	3.75	4.25
-range	0.25-6.0	0.75-6.5	1.5-6.5*	2.0-6.5*
Precipitation May 1-July 31				
-average	6.5	7.25	8.00	8.5
-range	2.0-11.5	2.2-12.5	2.8-14.0	3.0-15.0
Total available moisture				
-average	9.25	10.50	11.75	12.75
-range	2.25-17.5	2.95-19.0	4.3-20.5	5.0-21.5

The maximum for a clay soil may exceed 6.5” of water in these soil zones because clays have a higher water holding capacity than lighter textured soils.

Based on these available moisture levels and yield relationships, yields may vary widely, particularly in the driest regions [Table 3]. In extreme situations in the Brown soil zone, yield can be reduced to zero. This is much less likely to occur in the moister Black and Gray zones. Because moisture is received more reliably in these regions, fertilizer cutbacks are not warranted as frequently.

Another consideration that needs to be made, is the level of other inputs in use. There is little point in making dramatic cuts to fertilizer inputs when other inputs are at levels that support much higher yield. Ultimately, the factor that is most limiting on yield will determine the final level of production.

Table 3. Predicted* yield of wheat, barley and canola with average, low and high moisture conditions for soil zones of Saskatchewan.

Crop	Available moisture	Soil zone			
		Brown	D Brown	Black	Gray
Wheat	Average	24	34	43	55
	Extreme dry	0	4	11	18
	Extreme wet	57	68	80	96
Barley	Average	40	51	64	83
	Extreme dry	0	6	16	27
	Extreme wet	87	102	126	146
Canola	Average	17	25	36	46
	Extreme dry	0	3	8	15
	Extreme wet	38	51	62	81

*Yield predicted from formulas in table 1, and average, low and high available moisture from table 2 for each soil zone.

Data from another canola experiment conducted at Melfort, Indian Head and Scott provides a good example of this [Table 4]. At low fertilizer application rates, yield increased with increasing seed rates from 2.5 to 5 lb/ac, but no further increase at 7.5 lb/ac. However there was a response to the high seed rate at moderate and high fertility.

Similarly, at the low seed rate yield increased with increased fertility from the low to mid, but not mid to high rate. With mid and high seed rates, there was a yield response to high fertility. The highest yield was obtained with the combination of the high seed and the high fertilizer rate. Thus, optimum levels of one input were determined by the level of another input.

Overall, net returns favored mid to high rates of fertility combined with mid to high seed rates [Table 5]. High rates of one combined with low rates of the other tended to provide lower income. With the low seeding rate, net income became much more variable as fertilizer rates were increased.

Table 4. Canola yield response [bu/ac] to increasing fertility and seed rate [mean for 7 location years at Melfort Indian Head and Scott, Sask].

Fertility Level	Seed Rate [lb/ac]		
	2.5	5.0	7.5
Low [about 70% of soil test recc]	26.6e	29.8d	29.5
Mid [about 110 % of soil test recc]	28.8d	31.6c	33.3b
High [about 140% of soil test recc]	29.6d	33.4b	35.0a

Values followed by the same letter are significantly different at P=0.05

Table 5. Influence of fertility level and seed rate on net returns, and income variability* [mean for 7 location years at Melfort Indian Head and Scott, Saskatchewan].

	Net Returns [\$/ac]*			Index of income variability**		
	Seed Rate [lb/ac]			Seed Rate [lb/ac]		
Fertility Level	2.5	5.0	7.5	2.5	5.0	7.5
Low	75	82	77	120	96	98
Mid	92	96	99	140	100	95
High	82	101	105	192	120	105

*Net returns bases on cost from 2002 Saskatchewan Crop Planner, and canola at \$8/bu.

** Index of income variability is a relative value where the mid fertility and seed rate was set as 100, and values greater than 100 represent treatments that are proportionally more variable, and vice versa for lower values.

While fertilizer cutbacks may be an effective part of a strategy to cope with drought, long term cutbacks should be approached with caution. Grain crop production removes nutrients from the land, and unless they are replaced, the soil will eventually be depleted. In extreme cases, it may not be feasible or even possible to recover the lost yield potential by applying fertilizers.

In a long-term rotation experiment at Scott, yield of wheat on fallow in a fallow-wheat-wheat [F-W-W] rotation was measured with and without phosphate fertilizer applied. For a long period of time, unfertilized wheat yielded about 80% of fertilized wheat [Figure 6]. However, since the mid 1990's, yield of unfertilized wheat appears to be decreasing, while that of fertilized wheat is increasing. This suggests that P deficiency is becoming larger on the unfertilized plot, and is having a larger impact on yield

In the same experiment, yield of unfertilized wheat on stubble was lower than wheat on fallow, but followed the same trend over time until the mid 1970's. Since that time, yield of unfertilized wheat on stubble has tended to decline; a clear indication that fertility of the soil is decreasing. A same portion of the stubble plots that received P when in the fallow phase, have been fertilized with N and P since 1983. This fertilized wheat is now yielding as much as unfertilized wheat on fallow.

In another long-term experiment, a fallow-wheat [F-W] rotation was evaluated [Figure 7]. Prior to about 1970, unfertilized wheat in F-W yielded slightly more than similarly unfertilized wheat in the F-W-W rotation, but since the mid 1980's, has yielded considerably less. It is possible that more frequent fallow and not fertilizing has accelerated depletion of soil nutrients compared with F-W-W. Application of P fertilizers has only partially restored yield in the F-W rotation so that it is now intermediate between fertilized and unfertilized wheat in the F-W-W rotation.

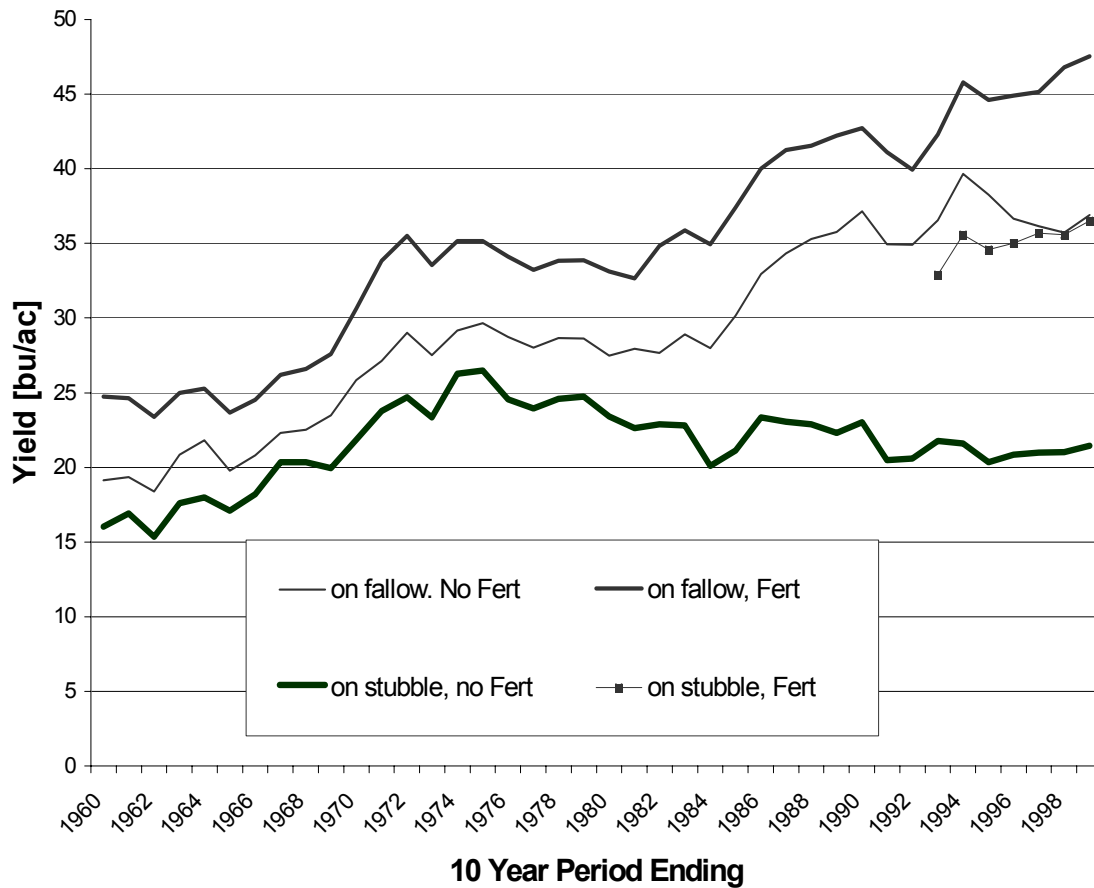


Figure 6. Wheat yield trends on fallow and stubble, with and without fertilizer in a long-term [started 1912] fallow-wheat-wheat rotation at Scott, Saskatchewan [data is 10 year moving average yield as bu/ac].

Summary

Some reduction in fertilizer rates may be appropriate when drought is anticipated. Available soil moisture on stubble in spring at seeding may be a useful indicator of when such cutbacks should be undertaken. Soil moisture at seeding could also provide an indication of the size of such cutbacks. Other factors that come into play are prices for grains and fertilizer. However, these factors have a much smaller influence on optimum fertilizer rates. Growers should be cautious about large cutbacks in response to these factors, because they could jeopardize investments in other crop inputs. When fertilizer cutbacks are made, growers should re-evaluate other inputs to determine if they should also be cut. Cutbacks in fertilizer rates could be a useful part of a short-term strategy to deal with unfavorable conditions. However, on a long-term basis there is risk

that soil nutrient levels could be seriously depleted. This could result in increased costs, along with reduced yield; a combination that could have drastic economic implications.

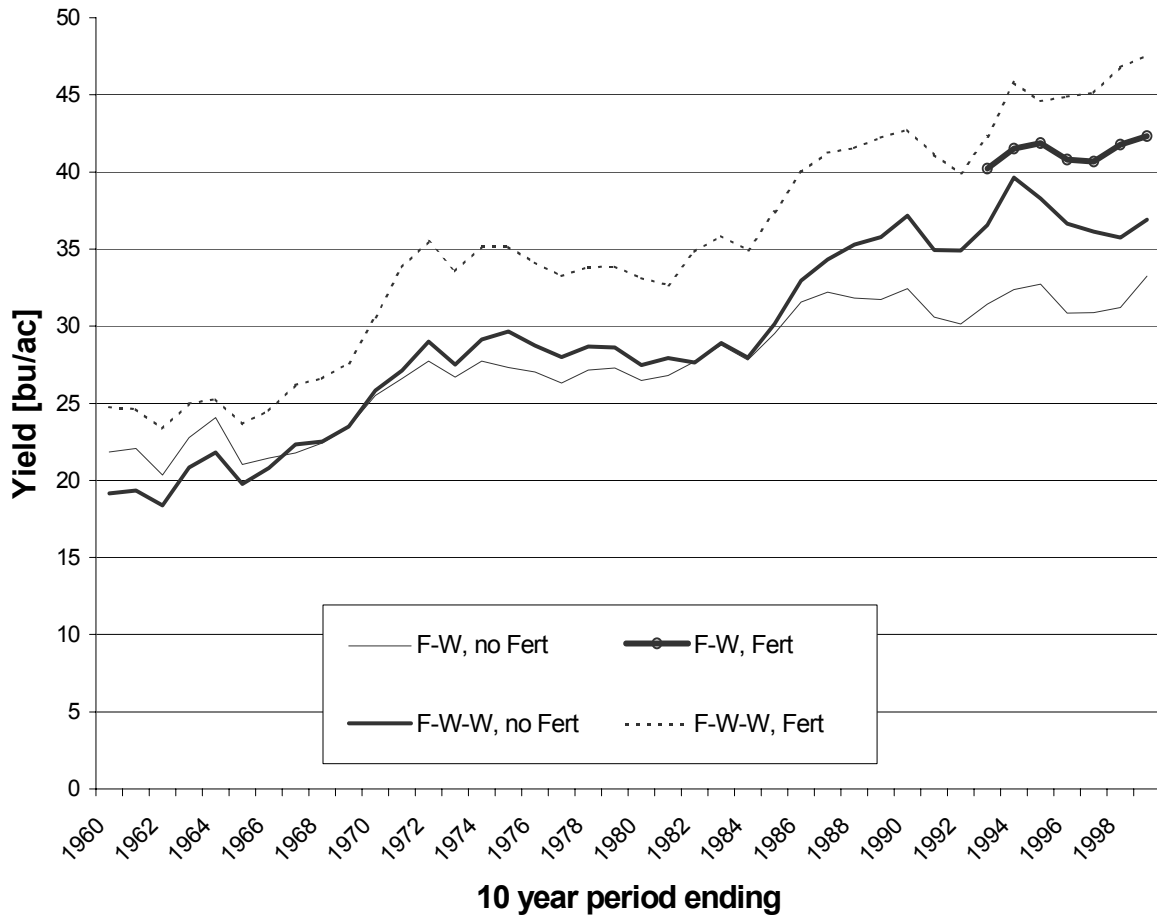


Figure 7. Wheat yield trends on fallow with and without P fertilizer in long –term fallow-wheat and fallow-wheat-wheat rotations at Scott Saskatchewan [data is 10 year moving average yield as bu/ac].