Fertilizer Cutbacks

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Fertilizers are used to supply nutrients that crops need, and the soil cannot supply. Fertilizers are particularly important where nutrients from the soil are limited, and where other practices target high yields.

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] and economic conditions. Soil testing and previous experience provide an estimate of the soil supply of nutrients, and of yield potential. Yields are mostly limited by the supply of moisture under our conditions. 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 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 and 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.

When moisture is abundant, little N is needed for wheat to utilize it efficiently [Figure 1]. Most of the N can be supplied by the soil [most of our soils could supply at least 30-50kg/ha], with little applied as fertilizer N. Under very favorable moisture, wheat will respond to very high levels of N. Under such conditions, most of the N normally needs to be supplied as fertilizer. The N rate needed for maximum yield is always higher than the rate needed to optimize economic return, because increased yield must always offset increased fertilizer cost. Where grain prices are low, the optimal amount of N is consistently lower than where grain prices are higher. However, grain prices tend to have a much smaller impact on the optimal level of N than does moisture stress. This means moisture conditions have a greater impact on optimum N rates than commodity prices.

While this example is for wheat, recent research with canola confirms a similar response. A 40% decrease in canola price only reduced the optimum N rate by about 15%, while a 40% reduction in available moisture reduced the optimum rate by about 40% [data not shown]. A 50% increase in the cost of fertilizer N only resulted in about a 10-15 % reduction in the optimum N rate for canola [Figure 2], indicating again the prices have a smaller effect than available moisture. However, the combination of low canola price and high N cost could reduce the optimal N rate by 25-30%.

Developing realistic yield estimates for upcoming crops is a critical part of fertilizer strategies. Useful equations to estimate yield based on the supply of water and how efficiently it is used in various soil zones are available.

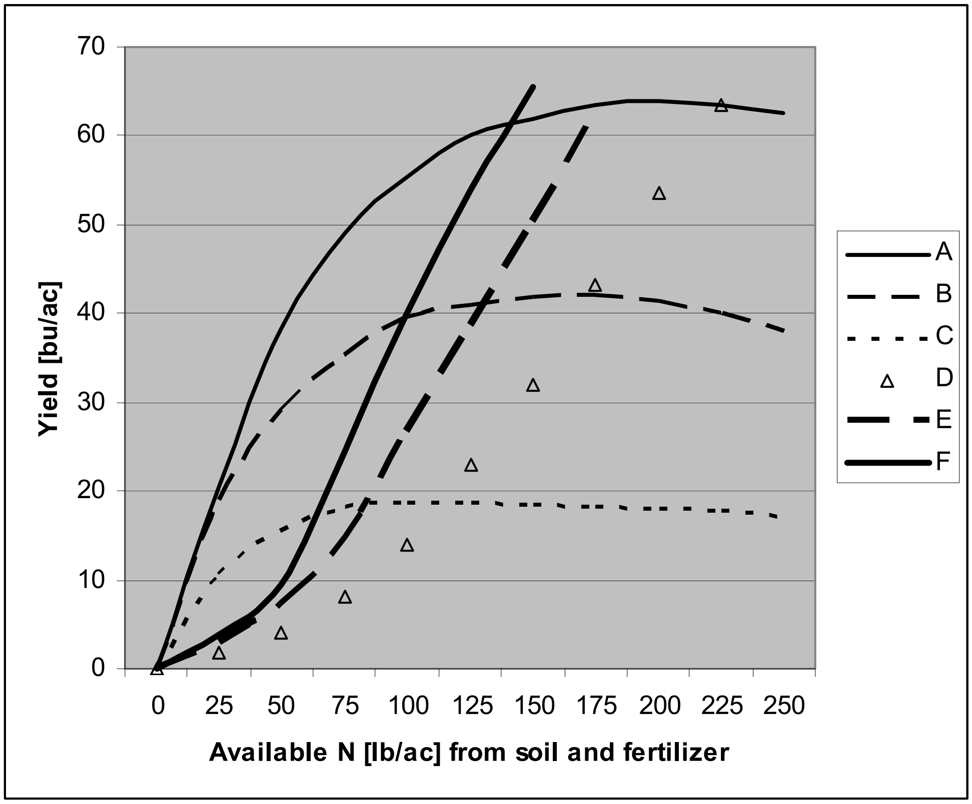

Figure1. Wheat yield response to nitrogen {soil N plus fertilizer N] with approximately **A**. 480 , **B**. 330 and **C**. 175 mm of available moisture from stored soil moisture plus growing season rainfall, and N rate required for **D**. maximum yield, **E**. optimum yield at $185/t or, **F**. $110/t for wheat. {Schematic adapted from

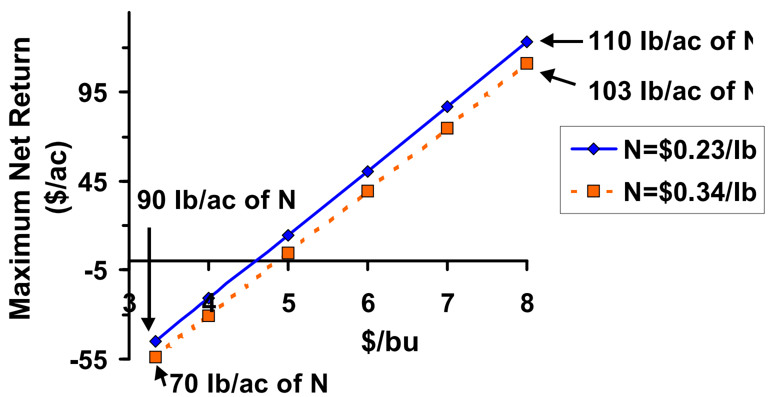

Figure 2. Canola net returns as influenced by fertilizer N costs with canola priced at 3 to 8 dollars per bushel. [Averages for Melfort, Indian Head and Scott during 2000 and 2001].

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)x3.5	Y=(WU-2.5)x5.3	Y=(WU-2.5)x2.0
Brown	Y=(WU-2.25)x3.75	Y=(WU-2.25)x5.7	Y=(WU-2.25)x2.5
Dark Brown	Y=(WU-2.0)x4.0	Y=(WU-2.0)x6.0	Y=(WU-2.0)x3.0
Thin Black	Y=(WU-1.75)x4.25	Y=(WU-1.75)x6.4	Y=(WU-1.75)x3.3
Thick/Gray Black	Y=(WU-1.5)x4.5	Y=(WU-1.5)x6.7	Y=(WU-1.5)x3.6
Gray	Y=(WU-1.25)x4.75	Y=(WU-1.25)x7.2	Y=(WU-1.25)x4.0

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 Saskatcewan 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 for typically drier {Brown] than wetter [Gray] regions. Thus water use efficiency is lower in those regions that are typically drier.

Similarly, both spring soil moisture on stubble and precipitation are 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 predicted reliably but soil moisture at seeding can be measured. Where fertilizer cutbacks are being considered, soil moisture at seeding can be used as a guideline in making yield estimates. 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.

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. Data from another canola experiment 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.

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.

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.

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].

	Seed Rate [lb/ac]		
Fertility Level	**2.5**	**5.0**	**7.5**
Low [about 70% of soil test recc]	26.6e	29.8d	29.5d
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.

Preliminary results of a study where inputs are removed one at a time from a full input package or are added to a low input package show some interesting responses [data not shown]. Reducing seed, fertilizer or herbicide rates in a full input package generally had a smaller impact on yield than similar increases in the same inputs when added into a low input package. This might suggest that there is greater potential to cut inputs where high yield is being targeted. Unfortunately, we don't have sufficient understanding of this issue to predict in advance the outcome of reducing input rates in individual situations, or the cumulative impact of such cuts over years. We expect that these studies will provide some answers in the near future.

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

In a long-term rotation experiment, yield of unfertilized wheat on fallow in a fallow-wheat-wheat [F-W-W] rotation was about 80% of phosphate fertilized wheat [Figure 3]. However, since the mid 1990's, yield of unfertilized wheat is decreasing, while that of fertilized wheat is increasing. This suggests that P deficiency is increasing 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 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 on stubble is now yielding as much as unfertilized wheat on fallow.

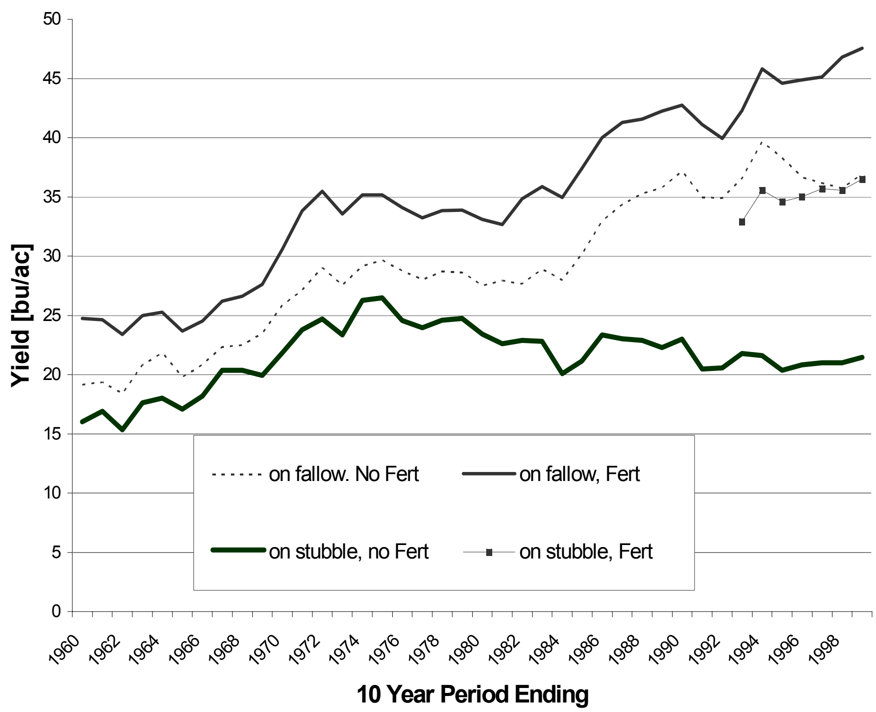

Figure 3. Wheat yield trends on fallow and stubble, with and without fertilizer in a long-term [started 1912] fallow-wheat-wheat rotation at Scott, Saskatchewan [data is 10 year moving average yield as bu/ac].

Summary

Some reduction in fertilizer rates may be appropriate when drought is anticipated. Available soil moisture on stubble 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 will have drastic economic implications.