Nitrogen
Phosphorus
Potassium
Sulphur

Answers To Your Questions

A Producer's Version

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Over the past several decades, considerable research has been done and many answers provided by the scientific community in the three prairie provinces on the use of macronutrients in crop production and on the environment (Rennie et al 1993 - Macronutrient Bulletin). Even so, many burning questions related to agronomy and soils remain to be answered to the satisfaction of producers and agrologists involved in technology transfer. This manual was developed in an attempt to provide a ready reference source that is "producer and extension agrologist friendly".

As a first step in preparing this publication, agronomists across the prairies were asked to submit examples of the questions related to N, P, K, and S that were asked of them by producers. The response to this request resulted in over 100 questions. Questions were then sent to soil and crop specialists for answers. Each respondent was asked to prepare their answer in such a way that they were factual, brief, and with only minimal scientific jargon, and to use as a reference where feasible, the 527-page macronutrient technical bulletin recently prepared by Rennie et. al. (1993). The editors are greatly indebted to these respondents; their efforts will be appreciated not only by producers but by those agrologists whose responsibility it is to facilitate communication and technology transfer. We would also like to thank Dr. R.P. Zentner and Mr. Roy Button for reviewing this manuscript.

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General

What are the natural levels of available nutrients (N, P, K, S) in different soils? How do these nutrients vary in each soil type? How do natural levels relate to geological development of soils?

Although this question asks for natural levels of nutrients in soil, we will answer in terms of the levels that are available to a crop because these are more important to the well being of the crop in any one year and are more dynamic.

The availability of nutrients, or for that matter, of any chemical element in virgin soils (those not brought under agriculture) depends on what soil scientists call, soil-forming factors. These factors are:

- climate under which the soil developed (which is not necessarily the same as present day climate)
- organisms that have lived in or on the soil (plants, microorganisms, insects, earthworms, etc.)
- relief or topography, including the position in the landscape (degree of slope)
- parent material, that is, the rocks or sediments that gave origin to the soil
- time (age of the soil)

In addition to these factors, when soils are brought into agricultural production, soil management factors (erosion, cropping system, fertilization practices) plays an important role in determining the level of available nutrient.

The levels of available nutrients vary widely within each soil zone, and even within a field. In addition, changes in growing conditions from year to year produce extremely large variations in certain nutrients within a single field.

A summary of data for Saskatchewan soil compiled by the Saskatchewan Soil Testing Laboratory indicates that the levels of available nutrients in Saskatchewan soils tend to separate the soils from different soil zones (see table below), and in the case of nitrogen, reflect the effect of cropping. However, the reader should note that these are average numbers that will vary widely from year to year and from field to field.

**Average available soil nutrient content of Saskatchewan soils (lb/ac) based on 23 years of soil analysis. N for top 2 feet of soil, P and K for the top 6 inches.**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil Zone</th>
<th>Brown and Dark Brown</th>
<th>Black and Gray Black</th>
<th>Gray</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fallow Stubble</td>
<td>Fallow Stubble</td>
<td>Fallow Stubble</td>
<td>Fallow Stubble</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>65 45</td>
<td>90 45</td>
<td>60 35</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>19 19</td>
<td>21 21</td>
<td>26 24</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>600 600</td>
<td>425 450</td>
<td>300 300</td>
<td></td>
</tr>
</tbody>
</table>
Similar trends are observed in Alberta and Manitoba soils. However, there are differences between the provinces, reflecting both different soil forming and soil management factors.

On the prairies, although K is seldom deficient, crop responses are often observed in light textured soils, particularly when cropped to forages or under irrigation. Sulphur deficiency is mainly found in Gray Luvisolic soils but, some coarse textured and degraded Chernozemic soils such as the thin Black, may also be deficient, particularly for canola production.

Why have organic matter levels been decreasing in many of our soils?

Research has shown that reducing the frequency of summerfallow in a crop rotation will reduce the rate of organic matter decline. Long-term research has shown that properly managed cropping systems that include fertilizer applications, legumes, reduced fallow and manure applications will increase crop production which will maintain or increase soil organic matter. In order to maintain sustainable crop production, additions of nutrients must equal or slightly exceed crop removal. Failure to replace soil nutrients will result in a decline in productivity of our soils.

What is the best way to replace nutrients exported from the farm?

Nutrients can be replaced through the use of green manure, animal manure and fertilizer applications. The best way to replace nutrients exported from the farm under the present cropping systems across the prairies is to use fertilizers. Fertilizers supply nutrients which can be taken up directly by plants or undergo transformations in soil into forms the plant can use. Using fertilizers allow us flexibility and we can apply appropriate amounts of N, P, K, and S according to identified needs. Release of nutrients from fertilizers occurs in a predictable manner, allowing application rates of fertilizer to be closely matched to crop needs. Legumes, properly inoculated, can be used to supply nitrogen, but they supply no P or S which must therefore be supplied by fertilizers or other means.

What is the best fertility program to use to improve knoll productivity where erosion and low organic matter have reduced productivity?

Reduced soil productivity on eroded knolls is the result of the loss of soil fertility (the nutrients have been washed or blown away with the topsoil), and the impairment of soil physical properties conducive to proper plant growth (soil structure, water holding capacity, water infiltration, porosity, etc.). Fertilization will enhance yields, but by itself fertilization will not fully restore productivity. Therefore, to restore productivity of eroded knolls, we must adopt a complete management package oriented to rebuilding the topsoil.

One of the first things that can be done is to reduce mechanical tillage to reduce the risk of further erosion. At the same time, steps should be taken to improve the soil tilth to allow the plants (more specifically the plant roots) to have a more favorable environment for growth. This can be achieved by applying organic residues that would permit the formation of soil organic matter. In this respect applications of manure...
would be beneficial. Application of other organic materials that have lower nutrient content than manure would require the application of added nutrients (fertilizer) to allow the soil microbes to function properly and build organic matter.

In addition to application of organic amendments, a move towards extending crop rotations with proper fertilization of eroded areas will increase the organic matter content of the knolls. In some cases, a more economical and perhaps more effective way of restoring the productivity of eroded areas is to take them out of grain production and put them under a permanent forage cover. The combined effects of permanent grass or grass-legume cover and the application of animal manures will increase the productivity of these areas faster than if maintained under annual crop production.

**What is the effect of fertilizer in drought years? How efficiently do plants use water in these circumstances?**

In the Prairies, there is usually enough water reserve in the soil in the spring to initiate healthy and vigorous plant growth. Dry periods sometimes occur later at about the flowering to grain filling stage, especially in the Brown and Dark Brown soil zones. In these dry areas, crops grown on stubble, irrespective of whether they are fertilized or unfertilized, will invariably use all the available water in the root zone. Fertilizer mainly affects the rate at which available water is used. If we regard water use efficiency as the ratio of grain yield: water used, then fertilization will result in higher efficiency whenever it results in increased yields. In the Brown and Dark Brown soil zones we can expect an increase in water use efficiency due to fertilization, in most years (See table below). However, in dry years, yields of fertilized and unfertilized systems are often similar, as will be the amount of water used, and thus water use efficiency will also be the same. In the drier parts of the Brown soil zone this situation can be expected to occur in 3 of every 10 years, but in the moister Dark Brown and Black soil zones it will rarely occur.

**Effect of fertilizer on water use efficiency in various soil zones in Saskatchewan.**

<table>
<thead>
<tr>
<th>Soil Zone</th>
<th>Water Use Efficiency (bu/ac/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>Brown</td>
<td>2.12</td>
</tr>
<tr>
<td>DarkBrown</td>
<td>2.28</td>
</tr>
<tr>
<td>Black</td>
<td>2.05</td>
</tr>
<tr>
<td>Gray</td>
<td>1.18</td>
</tr>
</tbody>
</table>

**Can fertilizer use efficiency be improved?**

Adoption of best management practices which lead to moisture conservation and efficient soil water use will lead to improved fertilizer use efficiencies. Practices such as proper crop rotations, soil nutrient testing, weed control, snow management, conservation tillage, variable rate fertilization, as well as others, when incorporated into a total management package, will lead to improved fertilizer use efficiencies, enhanced crop production and environmental protection.
Are fertilizers toxic to plants?

Fertilizers, when applied at rates matched to crop requirements through soil test, are not toxic to plants. If higher than recommended rates are applied injury to plants can occur. A best management practice is to test your soil for plant available nutrients and then match application rates and placement to meet the requirements of the crop.

Do liquid fertilizers work better than dry fertilizers?

No. Research work conducted in western Canada has indicated that there is no additional agronomic benefit to using liquid fertilizers instead of dry fertilizers. Both forms of fertilizer are equally effective in supplying plant available nutrients. There is no known agronomic advantage to having fertilizers supplied in the liquid form. When applied to the soil, both forms will be subjected to the same processes and transformations to become equally available to the plant. The decision of whether to use dry or liquid fertilizer should be based on the availability of equipment, cost of the material, storage and handling cost, and the ease of application.

Is it safe to blend all granular fertilizers?

No. Do not mix urea or fertilizers containing urea with ammonium nitrate or fertilizers containing ammonium nitrate. Such mixtures will quickly become wet and unmanageable. If you are unsure of fertilizer compatibility check with your local fertilizer retailer. Most fertilizer retailers in western Canada have fertilizer blending equipment and are knowledgeable as to what granular fertilizers can be safely blended together.

To ensure uniformity of granular fertilizer blends, blend only products that are similar in size and weight. This will help reduce blend segregation and ensure that the proper amounts of nutrients are applied uniformly across the field.

Can I apply herbicides with my fertilizers?

Certain herbicides can be applied with some fertilizers; however, it is advisable to check with your local herbicide/fertilizer retailer or extension agrologist to determine if a particular herbicide/fertilizer combination is registered for use.

How much fertilizer is used in western Canada?

The following table lists the amounts of common farm fertilizers that were sold in western Canada in the 1991-92 fertilizer year. The amounts and rates of fertilizers used on the prairies have increased steadily from the 1950’s to the mid-1980’s, but have levelled off in recent years in response to the agricultural economy.
Volume and types of fertilizers sold in western Canada (1991-92)

<table>
<thead>
<tr>
<th>Product</th>
<th>Volume ('000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous ammonia (82-0-0)</td>
<td>495</td>
</tr>
<tr>
<td>Urea (46-0-0)</td>
<td>945</td>
</tr>
<tr>
<td>Ammonium nitrate (34-0-0)</td>
<td>205</td>
</tr>
<tr>
<td>Monoammonium phosphate (11-55-0)</td>
<td>845</td>
</tr>
<tr>
<td>Ammonium sulphate (21-0-0)</td>
<td>165</td>
</tr>
<tr>
<td>Muriate of potash (KCL) (0-0-60)</td>
<td>115</td>
</tr>
</tbody>
</table>

Are there any problems with using animal manure as a fertilizer?

Like any fertilizer input, when properly managed, manure can adequately supply some crop nutrients. However, the nutrient content of manure is usually low and variable and the conversion of the nutrients into forms that the plant can use is difficult to predict. Further, the nutrients are not necessarily present in the ratio the crop requires. Due to these problems and the limited supply of manure on the prairies, only areas adjacent to feedlots usually receive a high enough application to supply crop needs. Another precaution with the use of feedlot manure is that it can contain high numbers of weed seeds and salts which can contaminate soils and add to production costs. Nonetheless, manure can be an invaluable input when it is applied under certain conditions, because it is a good source of organic matter which will improve the physical and biochemical properties of the soil. For example, manure can be very effective in ameliorating nutrient and structural deficiencies of eroded soils.

Are organic nutrient sources more available to the plant than synthetic fertilizers?

All nutrients are taken up by plants in the inorganic form, which is the form supplied by most fertilizers. Organic nutrient sources must be converted by soil microorganisms into the inorganic form before they can be used by plants. This conversion process takes time and is governed by factors affecting the biological processes in the soil. Once the nutrients are in the inorganic form the plant cannot differentiate between the original sources and both are equally plant available.

Is leaching of nutrients a problem?

It may be, particularly if no plants are growing, i.e., in fall, spring prior to seeding, or on fallow. The answer depends upon the nutrient and the situation. Mobility of phosphorus is very low in soil so it is not leached readily. Potassium (K) and ammonium-nitrogen (NH₄-N) are positively charged and tend to move slowly owing to their attraction to the negatively charged clay particles. Nitrate-nitrogen (NO₃-N) is negatively charged and leaches readily. Ammonium is converted to nitrate under moist, warm conditions so nitrate leaching is our greatest concern. Sulphate-sulphur (SO₄-S) is also negatively charged and subject to leaching.
Because there is usually insufficient rainfall in the Brown and Dark Brown soil zones and the rainfall is distributed uniformly over the growing season in Black and Gray soil zones of the prairies, leaching of crop available nitrogen and sulphur below the root zone is normally not a problem in medium or fine textured soils. However, on coarse textured soils, nitrogen and sulphur may move below the root zone, especially when applied in excessive amounts and when there are periods of heavy rainfall. On irrigated land, leaching may be serious, depending on the soil texture and amount of water used. Nitrogen leaching can be minimized by using proper fertilizer management, growing fall-seeded crops, and scheduling irrigation correctly.
Crop Requirements & Rotations

Is continuous cropping (monoculture cereals, or cereals-oilseeds) as good for the soil as using forage crops in rotation?

Research in various long-term crop rotations show that monoculture cereals, or cereals-oilseeds, are as good for maintaining soil fertility as is including forage crops in the rotation, provided the cereals-oilseed system is adequately fertilized, and summerfallowing is minimized. Of course, perennial forages should not be grown in rotations with cereals in the drier regions (e.g., Brown soil zone) because of water limitations for the succeeding cereal crop. On the other hand, monoculture cereals can succumb to disease infestation when grown continuously in humid areas. Any restrictions on crop production, and thus crop residues, will encourage soil degradation.

Nitrogen requirements of hard red vs. semi dwarf wheat, are there any differences?

Research in Saskatchewan and Manitoba show no differential fertilizer requirements for these two types of wheat. Fertilizer should be applied according to the yield goal and soil test for the field. There are differences in yield potential (semidwarfs are higher yielding) but this factor is taken into consideration in the yield goal. Also, because of differences in price for the two types of wheat, the economic optimum rate may differ.

What are the amounts of nutrients required by the major crops?

The table below shows typical nutrient removal by crops on the Canadian prairies. Higher crop yields would result in greater amounts of nutrient removal. In order to maintain sustainable crop production, these soil nutrients need to be replaced.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Crop part</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Sulphur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring wheat 40 bu/ac</td>
<td>Seed</td>
<td>60</td>
<td>23</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>25</td>
<td>9</td>
<td>55</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>85</td>
<td>32</td>
<td>71</td>
<td>9</td>
</tr>
<tr>
<td>Barley 80 bu/ac</td>
<td>Seed</td>
<td>78</td>
<td>34</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>28</td>
<td>9</td>
<td>68</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>106</td>
<td>43</td>
<td>93</td>
<td>12</td>
</tr>
<tr>
<td>Canola 35 bu/ac</td>
<td>Seed</td>
<td>68</td>
<td>41</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Straw</td>
<td>44</td>
<td>17</td>
<td>72</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>112</td>
<td>58</td>
<td>93</td>
<td>22</td>
</tr>
</tbody>
</table>
Should I put field peas and lentil on summerfallow?

Both peas and lentil are legumes, plants which are capable of fixing nitrogen from the air. Summerfallow results in mineralization of relatively large quantities of soil nitrogen, sufficient to suppress the nitrogen fixation process and causes the plant to rely on the nitrogen in the soil. Since inoculating peas and lentil with a nitrogen-fixing strain of bacteria is cheaper than applying nitrogen fertilizer, it would be more economical to grow peas and lentil on stubble land and grow a non-legume on summerfallow to take advantage of the mineralized nitrogen. Some producers are tempted to forego the advantage of “free” nitrogen in exchange for reduced weed population and more secure water supply. However, it must be remembered that lentil will continue to grow vegetatively and produce less seed if soil conditions are too “rich” during in the growing season. Extra nitrogen may also produce luxuriant vegetative growth which may encourage disease infestation.

I had peas or lentil last year, do I need fertilizer nitrogen this year?

Yes, usually! Peas and lentil obtain approximately one half of their nitrogen requirement from nitrogen fixation and the other half from the soil nitrogen pool. The majority of the nitrogen that peas and lentil produce is found in the seed which is not returned to the soil when the seed is marketed. There is some residual nitrogen left in the soil after these crops are grown, as a result of crop residue being returned to the soil. However, in order to determine the nitrogen requirement for the next crop a soil test should be taken.

Is fertilizer nitrogen required with lentil/peas?

No, but the seed must be properly inoculated with nitrogen-fixing microorganisms. Lentil, peas and other legumes used for their grain (pulse crops) do not return as much nitrogen to the soil system as do green manure or forage crops (copious, deep roots). This is partly because a major proportion of the nitrogen in the pulse crop is harvested in the grain. Although the pulse crop is adding fixed nitrogen to the soil, it is using and removing soil N. A 12-year study at Swift Current has shown that when grain lentil was grown in a 2-yr rotation with spring wheat, the pulse crop gradually increased the nitrogen supplying power of the soil so that requirement for fertilizer nitrogen was reduced in later years of the study. Similar information has been reported from other regions of the prairies. Note: If soil mineral nitrogen is very low at seeding of lentil, the crop will benefit from a small (10-20 lbs/acre) application of N.

How does available nitrogen (soil or fertilizer) influence grain protein? Can we manipulate protein by managing fertilizer, e.g., to obtain low protein barley?

The nitrogen applied to cereals serves to increase grain yields and increase grain nitrogen concentration (protein concentration). To understand how nitrogen affects protein you need to remember two factors: (i) cereals take up nitrogen much faster than they accumulate dry matter, and (ii) the protein concentration of grain depends on the relative amount of starch produced compared to the nitrogen available to supply the grain. Usually protein will be high if nitrogen fertility is high. It will also be high if conditions are
dry and/or hot during grain formation and filling. The nitrogen the plant takes up early (i.e., before shot blade) goes to determine yield and protein, but the nitrogen it takes up later (e.g., from shot blade and after) mainly goes to increase protein. When moisture is excellent, high soil nitrogen early in crop growth can produce excellent yields without protein being excessive (starch dilutes N), but high late nitrogen will invariably lead to high protein. High moisture and low or moderate nitrogen will result in low protein. Under irrigation, it is possible to manipulate grain protein, but dryland cropping is at the mercy of rainfall and temperature. In the Brown and Dark Brown soil zones, protein will almost always be high because of low moisture and high growing season temperatures.
**Nitrogen**

*What is the “best” source of N?*

The major sources of nitrogen used in western Canada are anhydrous ammonia, urea, ammonium nitrate, ammonium sulphate and nitrogen solutions. The first two fertilizers listed account for the bulk (i.e., approximately 90%) of the nitrogen supplied by nitrogen products. Nitrogen solutions contain approximately equal amounts of urea and ammonium nitrate. When used properly, all nitrogen sources are considered to be equally effective. In other words, a pound of N, is a pound of N, is a pound of N. However, there are specific situations in which each of the products can have advantages and disadvantages. The strong popularity of urea and anhydrous ammonia among prairie farmers is due to the fact they cost less per unit of nitrogen despite the fact that more care is required in the application of these products. Since urea and anhydrous ammonia supply nitrogen in the ammonium form, these products are also preferred for fall band applications. Form of nitrogen is not usually critical for spring band applications. Ammonium nitrate is the top performer where nitrogen fertilizer is broadcast and left on the surface of the soil (i.e., forages and top-dressing for annual crops). This source of nitrogen also has advantages when higher rates of seedrow fertilizers are being considered. For example, safe rates of ammonium nitrate (34-0-0) when seed-placed are about 25% higher than urea (46-0-0). Ammonium sulphate is very popular where nitrogen plus a reliable, quick-acting source of sulphur is required. Nitrogen solutions are popular among some farmers because of handling advantages. From the foregoing it can be seen that the “best” source of nitrogen depends on the specific soil and crop situations and the type of fertilizer management program that is preferred by the farm manager.

*What is the effect of anhydrous ammonia on soil?*

When anhydrous ammonia is applied to a soil, there is a very high ammonia concentration within 1-2 inches of the point of application. Most soil organisms present in that concentrated ammonia zone will be destroyed. Then, as ammonia diffuses away from this zone, soil organisms from the rest of the soil volume begin to work at the edge of the high ammonia zone and convert the ammonia to nitrate. Over the years, there is no significant effect on the total soil population of organisms. In fact, like plants, microorganisms will respond positively to the nitrogen applied as anhydrous ammonia or any other source of nitrogen.

In the very concentrated zone of nitrogen, the pH of the soil will temporarily be very high and some dispersion of soil organic matter can result. However, on a total soil volume basis, the effect is negligible and anhydrous ammonia does not “burn out” the organic matter nor does it make the soil hard.

With any ammonium form of nitrogen (and all of our nitrogen fertilizers have some ammonium or are ammonium-forming), the long term result of very high rates of application would be a reduction in the soil pH. That is to say, it would tend to make the soil slightly more acid. Where soils are acid to begin with, the acidifying effect of ammonium types of fertilizers is taken into account in the quantity of lime applied. Throughout much of western Canada soil acidity is not much of an issue. In west-central...
Saskatchewan, central Alberta and the Peace River country, there are some acid soils that require liming and the long-term acidifying effect of ammonium types of fertilizers must be considered.

Generally, most prairie soils are well buffered against changes in pH (high clay, lime content). Further, rates of nitrogen used are so small that negative consequences of the sort mentioned here will rarely be a problem.

**What is the appropriate placement and timing of anhydrous ammonia?**

Anhydrous ammonia is best applied in late fall if the soil is not too dry. Spring application should be made at least one day before seeding. When anhydrous ammonia is placed in the soil, it creates a high ammonium concentration reaction zone within 1 or 2 inches of the application point. The shape of the ammonia zone will vary depending on the porosity of the soil and will not be a perfect sphere. As well, the zone of high ammonium concentration will usually be pear-shaped with the top of the pear occurring above the point of application. Ammonia should be placed deep enough in the soil that the high ammonia concentration zone is beneath the soil surface. On very sandy soils, this might be 4 to 5 inches, whereas on a high organic matter clay soil, 3 inches might suffice.

When placements are made at or near the time of seeding, extra care must be taken to ensure that the placement of the seed is well removed from the placement of the ammonia.

**Is anhydrous ammonia dangerous to handle and use?**

The corrosivity and high vapour pressure of anhydrous ammonia make it imperative that each person involved be aware of the associated risks. Such individuals must be properly trained and certified in the safe handling of this product. Ammonia is safe when properly used. It is important, however, to know the properties of this product and to handle it in the manner prescribed in industry sponsored training courses. Replace worn or old hoses to avoid the risk of permanent damage to eyes, nose, lungs and skin.

**Do cold, wet conditions lead to loss of nitrogen under zero tillage conditions and will this mean I will need to apply more N?**

Field research has shown that in the spring, in particular, accelerated loss of nitrogen through denitrification is more likely to occur under zero tillage as compared to tilled soil conditions. This is primarily due to the higher moisture content in the surface layer of zero tillage soils. Rates of denitrification are markedly influenced by moisture content. Notwithstanding this, the wetter soil conditions prevailing under zero tillage do not lead to accelerated loss of fertilizer nitrogen as the nitrogen is traditionally knifed into the soil, and denitrification loss of fertilizer nitrogen applied in a concentrated band is essentially negligible.
How much nitrogen applied as fertilizer is used by the crop? How much is lost and where does it go?

The proportion of fertilizer nitrogen applied that is recovered by the crop in the first year after application varies with many factors, including weather, fertilizer management (e.g., source, time of application, placement, rate of N), type of crop, etc. Under Canadian prairie conditions, fertilizer nitrogen recovered in the plant in the first year rarely exceeds 50% and averages about 37% under rain fed conditions. About 33% of the nitrogen is immobilized (organic N) where, over time, it gradually builds up the nitrogen supplying power of the soil so that in later years less fertilizer nitrogen will need to be applied. The remaining 30% of the nitrogen is lost from the system via various possible mechanisms (e.g., volatilization, denitrification, and leaching beyond root zone). Generally, the proportion of fertilizer nitrogen recovered in the grain decreases as nitrogen applied increases. Nitrogen recovery increases if nitrogen is banded (compared to broadcasting), if nitrogen is applied near seeding, and if moderate rainfall is received soon after fertilizer nitrogen application (too wet or too dry reduces recovery). The more robust the crop growth, the greater will be the nitrogen recovery by the plant.

Do I need to add extra nitrogen if I incorporate crop residue such as straw?

Yes. In the more humid areas of the prairies (e.g., the Black and Gray soils) where straw produced is usually heavy and the soil mineral nitrogen is used up by the preceding crop, the current crops will look yellow (N deficient) early in the summer unless you apply adequate fertilizer N. This can also occur in drier areas of the prairies but is not as frequent a problem. The reason for this N deficiency is that cereal straw is composed of material that is very high in carbon and low in nitrogen (wide C/N ratio of 80/1 to 100/1). During decomposition of materials with wide C/N ratios, mineral nitrogen (nitrate and ammonium) is used by soil microorganisms to release energy and the N is converted into microbial tissue which has a much narrower C/N ratio (4/1 to 10/1). The soil testing laboratory already takes this “tie-up” factor into account in providing their nitrogen recommendations, so the key is to soil test.

How can I minimize nitrogen leaching on irrigated crops?

There are several things that can be done. Use ammonium forms of nitrogen which are subject to leaching only after conversion to nitrate; apply nitrogen as close to seeding date as possible, and schedule irrigation to maximize nutrient uptake—lighter and more frequent irrigations are best. In severe cases it may be necessary to split the nitrogen application into two or three increments. Split application will work best on long-season crops such as corn, but too late an application (after flowering) will mainly increase protein, not yields.

Are there any difficulties encountered with using urea?

Urea (46-0-0) is more subject to volatile losses than ammonium nitrate (34-0-0) when broadcast and left on the soil surface. Urea hydrolyzes to ammonium and this can be lost as ammonia gas. Losses are greatest when urea is applied to a moist soil surface or thatch followed by several days of warm drying
conditions. Rainfall of at least 6 mm (0.25 inches) within one or two days of application will minimize volatile losses. In contrast, a very light shower followed by warm drying conditions may increase rather than reduce losses. High soil pH (>7.5) encourages volatile losses. One must also be careful when applying seed-placed urea because it is more harmful to seedlings than ammonium nitrate and it can cause seedling damage if rates are even moderately high. Crops such as winter wheat are particularly at risk.

**Last year was dry; will nitrogen carry over or will I have to apply more?**

Nitrogen carryover in dry years is highly variable. You should not assume that nitrogen carry-over has occurred and that nitrogen rates can be reduced after a dry year because this is risky. Therefore soil tests should be used to determine if significant carryover has occurred.

**What are the economics of broadcasting extra nitrogen after direct seeding? Are weeds being fertilized more than the crop, especially in wide row spacings on seeders?**

Crop response to extra nitrogen broadcast after seeding is variable. If urea is used, rain is required within a few days of application to prevent volatile losses. Also broadcast nitrogen is more subject to immobilization (N is not available for crop use during initial decomposition of crop residues) than banded or seedrow N. Broadcast nitrogen is generally more available to weeds than banded or seedrow N. Response to broadcast nitrogen after seeding has been more consistent with conventional tillage systems in the wetter parts of the prairies.

**What motivation do farmers have for improving nitrogen use efficiency?**

Improved nitrogen use efficiency results in a greater increase in grain yield or protein for each unit of nitrogen applied. If 2 lbs of nitrogen are required to increase the yield of wheat 1 bu/ac, varying fertilizer use efficiencies have a significant impact.

**Example 1:**  
At 30% fertilizer use efficiency (FUE)  
2 lb N/bu x (100/30) = 6.7 lb N/bu

**Example 2:**  
At 50% fertilizer use efficiency (FUE)  
2 lb N/bu x (100/50) = 4.0 lb N/bu

If N fertilizer costs $0.20/lb, the fertilizer cost is:

6.7 lb N/bu x $0.20/lb = $1.34/bu for Example 1  
4.0 lb N/bu x $0.20/lb = $0.80/bu for Example 2
Nitrogen - Organic

Are there organic alternatives to the common inorganic fertilizer nutrients?

No, not across the prairies. In western Canada the main alternative to the use of synthetic fertilizers are summerfallow, green manures, barnyard manures and sewage effluent. Intensively tilled summerfallow has been clearly shown to be an unacceptable alternative as it has been the major factor leading to rapid soil degradation. Extended cropping with prudent applications of fertilizers are key ingredients of sustainable farming.

Legumes offer an alternative to the use of nitrogen fertilizer because they have the ability to fix atmospheric nitrogen. Legumes provide no phosphorus and thus, where they are used, phosphorus must be added regularly. Farmyard manures offer an alternative source of all crop nutrients but it is only a theoretical alternative since it is in such short supply. Sewage, while it contains valuable plant nutrients is, in reality, in short supply across the prairies. Furthermore, it may supply anti-plant quality factors such as heavy metals which may be toxic to animals and man.

As we move to more reduced tillage, can an increase in organic nitrogen (soil organic matter) be expected? How may this influence fertilizer requirements?

Yes. In conventional tillage, there is more surface soil disturbance than in zero tillage. This leads to more rapid decomposition and mineralization of crop residues and soil humus in tilled systems, and so greater amounts of mineral nitrogen (plant available N) is produced in tilled systems in early years. After switching to zero tillage, a soil test would indicate a greater need for fertilizer nitrogen in the zero till system in the early years. This is because the conserved residues in zero tillage tend to promote the tie-up (immobilization) of mineral nitrogen by soil microorganisms. After several years, this tie-up is beneficial, because it gradually increases the nitrogen-supplying power of soils and in later years, requirements for fertilizer nitrogen will be less than under conventional tillage. These change overs occur more rapidly and are more evident in humid areas (e.g., Black soil zone). In drier areas, such as the Brown soil zone, we rarely see differences in nitrogen requirements due to tillage for a long time, because immobilization is limited.

How much nitrogen is contained in soil organic matter? How can I predict when it will be converted into nitrate?

This is a more complex question than it appears. The second part of the question has been a major area of nitrogen research by soil scientists for decades. Topsoil across western Canada contains between 2000 and 10,000 lb/ac of N. But, to predict how much mineral nitrogen (ammonium and nitrate) we can get from the organic matter in a soil is not easy. This is because:

(i) Not all the organic nitrogen is readily convertible to mineral N; in fact, only about 5-15% of the
total nitrogen is “active” or potentially available. This “active” nitrogen fraction can be estimated—generally it is greater in Black soils than in Brown and Dark Brown soils, and greater under zero tillage or minimum till than in regularly tilled soils.

(ii) The amount of nitrogen that will be mineralized depends on weather factors, especially moisture, temperature, and aeration and the first two factors are not easily predicted, though we could use historical information to provide probabilities. Scientists do have equations that will allow them to make estimates of how much nitrogen a soil will mineralize, but they have not yet been satisfactory for incorporating into soil testing recommendations. Some soil test laboratories are now attempting to take some of these varied factors influencing nitrogen dynamics into their fertilizer nitrogen recommendations.

**Do fertilizer nutrients play a role in maintaining soil organic matter?**

Yes. A large number of studies have reaffirmed the steady and, in some cases, alarming decline in both soil organic matter quality and quantity associated with the traditional tillage fallow rotations. The optimum use of fertilizer nutrients results in substantial increases in both grain, and above ground straw and root growth. These two latter products not only lead to an increase in total soil organic matter and in the quality of that organic matter, but also indirectly contribute to an increase in the ability of the soil to release nutrients, such as nitrogen, for future crop uptake.

**Is loss of nitrogen due to denitrification serious across the prairies?**

The conditions leading to serious loss of soil and fertilizer nitrogen due to denitrification have been well defined for prairie conditions. Denitrification is primarily an anaerobic process although small amounts can occur even on well aerated soils. The anaerobic (low oxygen) conditions found in saturated or flooded soils can lead to the almost total loss of all nitrate nitrogen within a few days. A good example is when heavy rains, after the crop emerges, causes ponding and results in very yellow looking nitrogen-deficient plants. At the other extreme, moderate to dry soils such as those prevailing under a growing crop will reduce denitrification losses to almost zero. Significant amounts of nitrogen can be lost by denitrification on fallow fields as the moisture content is usually higher where no plant growth is occurring. Similarly, denitrification losses are traditionally much higher on lower slope positions than on the tops of knolls, again due to the higher moisture content in the latter position. Denitrification is always more rapid at higher temperatures. Denitrification losses can be substantially reduced by banding fertilizer nitrogen as compared to broadcast and incorporation. Denitrification can be as much as 50% higher under zero tillage as compared to conventional tillage conditions. Thus, the potential benefits of zero tillage in a fallow rotation must be weighed against a risk of increased loss of soil nitrogen by denitrification. Band placement of nitrogen will, therefore, be more important under zero tillage than under conventional tillage, particularly under wet conditions.
Why is banding of phosphorus fertilizer so important?

When fertilizer P is applied to soil it is rapidly tied-up and becomes relatively unavailable to plants. The tie-up is greater when P is broadcast compared to banded. Thus fertilizer P should never be broadcast except on perennial forage crops. Efficiency of broadcast phosphorus can be especially low in calcareous or strongly acid soils. Banding reduces the contact between the soil and the fertilizer particles, thereby reducing soil adsorption and slowing the formation of insoluble phosphate compounds which reduces availability to plants. Plants normally take up most (90%) of their phosphate requirement in the first 40 days of growth. Therefore, placing the phosphorus in a band near to or with the seed has proven to be very beneficial to plant growth and yield.

How much phosphorus can I place with the seed?

Phosphorus fertilizers do not have a large “salt” or “toxicity” effect on seeds or seedlings. Cereal crops can receive phosphorus fertilizer at rates of 80 to 100lb/ac P₂O₅ even though in most instances only 20 to 30lb/ac P₂O₅ is needed. However, for crops such as peas, and canola only 20 lb/ac P₂O₅ can be placed with the seed. For some crops such as flax, placing even 10lb/ac P₂O₅ with the seed lowers yields and thus flax should be fertilized with phosphorus only when the phosphorus is banded below or to the side of the seed. Note: the common sources of P fertilizers available on the prairies have some N.

What happens to the extra fertilizer phosphorus that is not used by the crop in the year of application?

The phosphorus fertilizer not used by plants in the year of application has beneficial but somewhat reduced effects on subsequent crops. Even though the plant availability of applied phosphorus decreases with time, single large applications of phosphorus (100-200 lb/ac P₂O₅) can have beneficial effects on yields for periods of up to 8 years or more. For example, researchers in Manitoba and Saskatchewan found good residual effects from one-time application of 90 lb/ac P₂O₅. It should be noted, however, that in instances in which a single large application of phosphorus is added, annual applications of small amounts of P placed with or near the seed are usually needed for maximum economic yields.

When describing the pop-up effect, what exactly is meant by cool moist soils?

The supply of phosphorus from soil to the plants is greatly affected by soil temperature and moisture. Release of phosphorus from soil surfaces and movement to the plant roots is reduced with decreasing soil temperature and soil moisture. Moist or wet soils in early spring tend to be colder than normal and this retards the rate of root exploitation of the soil. Thus, under low temperature conditions phosphorus uptake
from the soil by plant roots is limited and a greater phosphorus deficiency exists than would otherwise exist under normal soil temperatures. Phosphorus added with or near the seed is more readily available, thus it will alleviate this phosphorus deficiency and result in a yield increase. The soil temperature at which a "pop-up" effect is observed cannot be exactly defined. Soil temperatures of about 5-8°C would be cool, whereas soil temperature of 10-12°C would be more normal.

Is it true that responses to applied phosphorus fertilizers is much less today than previously?

In field trials carried out prior to 1970, the probability of obtaining a yield response to phosphate fertilizer across a broad range of Saskatchewan soils was high; the probability of obtaining a yield response of 4 bu/ac was 48% and 71% on stubble and fallow, respectively. Trials conducted since 1970 suggests a decline in the frequency of obtaining a yield response to 32% and 48% for stubble and fallow, respectively. An increase in residual fertilizer phosphorus is one of several reasons suggested for this reduced phosphorus response. Of interest, is the observation that responses to phosphorus in Manitoba are probably as great today as in the past. Comparative values are not available for Alberta.

Do some soil types allow a greater response to phosphorus fertilizer than others?

Yes. Soils with a high organic matter content tend to release more phosphorus than soils low in organic matter. On the other hand, high levels of carbonates and high soil pH tend to increase the rate of fixation of added phosphorus above that of neutral-noncarbonated soils. Extremely acidic soils also tend to "fix" phosphorus at a greater rate than neutral soils. Thus, high-pH carbonated soils and extremely acidic soils will require more phosphorus over the long-term than noncarbonated soils, in order to maintain a particular level of plant available phosphorus. Phosphorus supply is also affected by soil texture. Fine-textured soils clays can supply more phosphorus to the plant than a coarse-textured soil at equivalent levels of extractable phosphorus (soil test-level). A fine-textured soil, however, will require more phosphorus fertilizer than a coarse-textured soil, to increase soil test phosphorus levels.

Phosphorus responses on my farm are variable, and not usually visually apparent particularly on stubble. Is phosphorus use of economic importance?

Nutrient levels, as well as other soil properties such as soil pH and organic matter can vary widely over relatively short distances in a field. Thus, response to fertilizers is variable. There is no doubt, however, that where soils have been heavily manured, or rates of phosphorus application have exceeded removal for periods of 10 to 20 years, the plant available phosphorus content of the soil will increase and response to phosphorus may be less. Soil tests should be taken to determine the amount of phosphorus fertilizer needed. Use of phosphorus fertilizer, at rates recommended based on soil tests, will provide net economic benefits over time. Even though responses to the added phosphorus may not be large on some fields, not using any fertilizer may result in a decrease in the plant available phosphorus content of the soil and lead to a requirement for higher rates in the future. Note: adding phosphorus every year (with the seed), at maintenance levels, will not only maintain soil available phosphorus levels needed for high yields, but will provide a yield increase due to "pop-up" effects in instances of phosphorus stress.
Note also that nitrogen and not phosphorus is usually the nutrient most limiting yield on stubble land. Thus, responses to phosphorus will not occur unless adequate amounts of available nitrogen is present.

**What is the minimum amount of phosphorus that should be added to have a growth effect?**

The minimum amount of phosphorus needed to have a growth effect (e.g., "pop up" effect) is about 10-15 lb/ac P₂O₅ for crops such as cereals. Application of 10 lb/ac P₂O₅ results in a fertilizer granule about every 2.5 inches of seed row, assuming 6 inch spacing between rows. Wheat seeded at normal rates, results in a plant every inch of row. Thus, some plants, especially during the seedling stage, would not have ready access to fertilizer phosphorus. Reducing phosphorus rates much below 10 lb/ac would result in very wide distances between fertilizer granules in the seed row and a large percentage of plants would have little access to fertilizer phosphorus.

It should be noted, however, that to maintain a sustainable agricultural system, nutrients removed by crops must be replaced. Grain from a 30 bu/ac crop of wheat contains about 18 lb P₂O₅. The amounts of phosphorus to be applied to maintain long-term productivity, would have to equal the amount removed by crops, plus phosphorus lost via erosion.

The amounts of nutrients (N, P, and K) in the soil may vary greatly over large areas. In general, nutrients near the soil surface are more readily available to plants than those in deeper layers, but the amounts removed by crops must be replaced. To determine the amounts of nutrients required to replace those lost by crops, soil samples should be analyzed to determine the current levels of nutrients. This information can then be used to develop a nutrient management plan for the farm.
What rates of fertilizer potassium are necessary to provide adequate nutrition?

The rate of potassium (K) fertilizer required to provide adequate crop nutrition depends on the level of plant available K in the soil, the individual crop requirement, and the expected yield level. Sandy and sandy-peaty soils are often K deficient and respond strongly to K fertilization. Rates of K required to provide adequate nutrition can best be estimated with the aid of a soil test, because rates of application can range between 0 to 200 lb/ac K₂O or greater.

When and how should potassium be applied for maximum effectiveness?

Low rates of K (10-30 lb/ac K₂O) should be placed with or near the seed at planting. Higher rates of K should be deep banded or surface broadcast either in the fall or spring prior to planting of annual crops, or broadcast applied or injected on forage stands.

What levels of potassium are safe to apply with the seed?

Potassium can exert a large “salt effect” on the young emerging seedling. Thus, the safe level of K that can be applied directly with the seed depends on the crop and the seeding equipment being employed. For narrow openers and crops such as canola, mustard, and flax, the generally considered safe level is 10 lb/ac K₂O, and for cereals the corresponding rate is in the range of 25 to 30 lb/ac K₂O. The total effect of all fertilizer placed with the seed must be considered when determining the safe level.

Does potassium have any effect on disease suppression and grain quality?

The addition of potassium chloride (KCl) as the potash fertilizer source may result in suppression of diseases, such as take-all, root rot and tan spot of wheat, common root rot, and spot form of net blotch of barley. In western Canada, research on chloride suppression of diseases has been inconclusive. Adequate K nutrition in balanced fertilization programs is required for high grain quality.

My fertilizer dealer says I should always apply a little potassium with the seed of barley. Should I?

On potassium deficient soils more than “just a little K” may be required to achieve optimum yield. On soils high in K, responses of barley to the application of small amounts of potash can occur. This is often attributed to greater tillering and perhaps greater straw strength.
**Sulphur**

**Do cereal and oilseed crops respond to sulphur in the Brown soil zone?**

Crop responses to sulphur in the Brown soil zone are rare and application of S fertilizer is seldom justified. Most Brown soils have significant concentrations of gypsum within the rooting zone. This S adequately meets crop demands for sulphur. Furthermore, crop demands for sulphur in the Brown soil zone are usually less than in other soil zones because of lower yield potential and the extensive use of cereals which have very low sulphur requirements. Note however, that crop responses to S frequently occurs in the more humid areas (Black, Dark Gray and Gray soil zones), particularly when canola is grown.

**Is there an interaction of sulphur with other major nutrients?**

All essential nutrients are interactive to some degree because of their mutual interdependence in plant nutrition. Sulphur shows a particularly strong interaction with nitrogen. Since both nutrients are used in relatively constant proportion for the synthesis of protein, one is directly dependent on the other. For example, application of excessive nitrogen fertilizer rates can increase the severity of sulphur deficiency.

**How can I identify sulphur deficiency?**

Sulphur deficiency in crops can be tentatively identified from foliar symptoms. In canola, sulphur deficiency is evident from a purple discoloration and cupping of leaves. Flowers tend to be pale yellow and pods are often empty. Other crops show chlorosis or yellowing, particularly of the new leaves. Visual symptoms alone, however, are not reliable indicators of sulphur deficiency since many other environmental or physiological conditions may induce similar effects. On canola some yield loss may occur before deficiency symptoms become apparent. Plant tissue analysis and soil test methods can provide more definitive identification of sulphur deficiency.

**Is sulphur fertilization of oilseeds and pulses on marginally S-deficient soils recommended?**

Yes. In soils where analyses indicate possible S deficiency, it is generally economical to apply a moderate rate of S fertilizer as insurance against yield loss. In such cases, producers are advised to leave check strips to monitor response and aid in fertilizer recommendations for subsequent years. A word of caution: S distribution in the field can be variable, being higher in depressions or saline areas, thus samples taken from these areas can throw off test results, indicating S is adequate for the field when in fact significant portions are deficient.
How much sulphur is required to correct a deficiency?

The recommended rate of sulphur fertilizer depends on soil S status, crop type, and fertilizer properties. Generally, S fertilizer requirements in very deficient soils range from 20 lb/ac S for cereals to 30 lb/ac S for oilseeds such as canola. For slow-release fertilizers such as elemental S products, somewhat higher rates may have to be applied and sufficient time must be allowed for the S to be oxidized to sulfates in the soil.

Is sulphur deficiency a widespread problem on the prairies?

Yes. Sulphur is the third most limiting nutrient to crop production on the prairies after nitrogen and P. Approximately 10 M acres of cultivated soils are deficient and 17 M acres are potentially deficient. These soils are located primarily in the Black, Dark Gray, and Gray soil zones. As well, coarse-textured soils are more S deficient than fine-textured soils.

Are all sulphur fertilizers equally available to crops?

A wide diversity of S fertilizer forms is commercially available. These various forms can be categorized into three general groups based on their rate of conversion to sulphate, which is the only form available to plants:

(a) Fertilizers containing soluble sulphate — These forms are immediately available for uptake by plants and therefore have high effectiveness in the short term.

(b) Fertilizers containing reduced sulphur in soluble form (e.g., thiosulphate). Thiosulphate and related S compounds are rapidly transformed to sulphate so that their short-term effectiveness is comparable to sulphate forms.

(c) Elemental S-containing fertilizers — Elemental S is the cheapest source of S, but it must be oxidized to sulphate before it is plant available. The rate of oxidation depends on a large number of factors, including the particle size of the fertilizers (the finer the particle size, the faster the conversion to sulphate). As a result, the effectiveness of these products in the short term may vary depending on product and soil conditions. In many cases, it is advisable to schedule elemental S applications several months early to allow time for oxidation to occur.

How much sulphur can I apply to canola? Can I apply sulphur and phosphate fertilizers together with the seed?

Recommended rates of sulphur for canola usually range between 15 to 30 lb/ac S. "Sulphate" should not be seedplaced with the phosphorus.
Why are crop responses to S fertilizer so variable from year to year, even on soils testing low in available S?

Most prairie soils contain large reserves of sulphur in the organic matter. As this organic matter decomposes, the sulphur gradually becomes available for plant uptake. The rate of sulphur release, however, is highly unpredictable and subject to the effects of climate, soil type, and cropping practices. For example, sulfate-sulphur (SO₄) leaches easily from soil. Therefore, sulphur deficiency will increase after heavy rainfall and deficiency symptoms will often appear in lower areas of sulphur deficient fields. This uncertainty reduces the precision of soil testing techniques.

A significant amount of sulphur may also be present in crop residues. For example, canola residues may contain almost enough sulphur to supply the sulphur needs of a subsequent cereal crop. Residues of the previous crop therefore add an additional source of variability.
Soil Testing

Why should I soil test every year?

Yearly soil sampling provides an indication of fertilizer requirements. Yearly soil testing is recommended primarily for nitrogen because the levels of this nutrient are subject to great fluctuations due to environmental and crop growth conditions. Soil test for other nutrients can be done less frequently (i.e., every two or three years), except where a specific nutrient problem is identified.

How important is soil sampling to obtain reliable fertilizer recommendations?

Proper soil sampling is the key to obtaining reliable recommendations on fertilizer nutrient requirements. Soil sampling must be carried out in such a manner as to reflect both field characteristics and management style and intentions. In fields with rolling topography, producers should decide whether they will address different slope positions differently or whether "mid-slope" positions represent the field. At a minimum, take 15 - 20 samples from each field independent of the size. In fields with a history of direct-seeding, or where fertilizer has been banded, a balance between samples taken from within seeding rows and interrow spaces is desirable.

What is the best time of year for taking soil samples for fertilizer recommendations?

Generally, the closer to the time of seeding a soil test is taken the more accurate is the assessment of nutrient availability. However, the database from which soil testing labs derive their plant nutrient recommendations are is based on either spring or fall soil samples. Soil samples taken in the mid-October to freeze up provide highly reliable fertilizer N, P, K and S recommendations; approximately 80% of the soil samples processed by soil testing labs in the prairies are taken in the fall. However, with the uncertainty of when freeze up may arrive, one may need to take samples even in late September.

Is any special consideration required when taking and handling soil samples for nitrate-nitrogen analysis?

Yes. If samples have to be transported to the laboratory in "moist" soil conditions special care must be taken to prevent the samples from becoming warm for an extended period because nitrate-nitrogen levels would be altered. Nitrate-nitrogen in samples that are kept at 22-25C for less than 48 hours undergoes very little change. If samples are to be kept for a longer period of time before transportation, they should be chilled (4 C) to reduce the rate of mineral nitrogen formation from organic matter. Alternatively, samples may be quickly air-dried by the user. In this case, lay the samples out on clean pieces of plastic or brown paper for a day or two to dry at room temperature. Placing an oscillating fan near the samples will speed drying. Care should be taken to prevent contamination of the soil by fertilizer or other material.
How do I determine the rate of fertilizer I should apply for different crops?

Soil testing laboratories normally provide the rate of "nutrient" application based on "common" and/or most efficient placement techniques for each crop requested. To obtain nutrient rates for different crops, simply request the crop options you are interested in from your soil testing laboratory. Nutrient rates can be converted to fertilizer rates by considering the composition of the fertilizer type(s) one intends to use. Tables for these conversions are available from the office of your extension agronomist or local fertilizer dealer.

Where can I get my manure analyzed for nutrients?

Most major soil and feed testing laboratories in the prairie provinces provide manure nutrient analysis. Consult your laboratory for more information on sampling techniques and sample submission.

Do changes in available N, P, K, and S occur with time, i.e., early, mid, or late fall or early spring, or just prior to seeding?

Generally, available nitrogen will increase from early to late fall if moisture and temperature are conducive to mineralization. If temperatures are very low in the fall, nitrogen increases will be small. Available nitrogen values are slightly higher in early spring compared to late fall. Available phosphorus is quite variable in soil. Although some reports suggest there are overwinter changes in available P, most reports say there are no conclusive predictable changes. There is no evidence of overwinter changes in available K throughout fall to spring. We are not aware of any studies that have reported overwinter changes for S, but S tends to behave like N.

Do all soil testing laboratories use the same units for reporting nutrient levels in soils?

No. Some laboratories express nutrient levels in the soil as parts per million (ppm), others as pounds per acre (lb/acre) and others as both ppm and lb/acre. The analytical results generated by all laboratories are initially expressed in ppm (or μg/g, mg/kg, etc.). When these results are communicated to the user, some laboratories prefer conversion to lb/acre, units that are familiar to most prairie producers, and which relate the nutrient levels to the associated fertilizer recommendations. Furthermore, it allows us to sum the amounts of nutrients in the various depths; this cannot be done easily with ppm. For micronutrients, the results are expressed in either ppm or lb/ac.

Is sampling the 0-6, 6-12 and 12-24 inch depths superior to taking one 0-12 inch sample for nitrogen?

Yes and no. Simple logic suggests that using the three sample units is better. As a matter of interest, the innovators of this test in Manitoba clearly showed that the best estimate of fertilizer nitrogen requirements for crops required sampling to a 4 foot depth. However, the added expense of taking 4 foot samples has
led to the 2 foot depth compromise and this depth was used in Manitoba and Saskatchewan until quite recently, while a 6 inch depth is used in Alberta. Today, however, most soil testing laboratories accept a 0-12 inch sample depth, but the deeper depth is recommended where salinity is suspected.

**Are nutrient forms reported in soil test results the same as those reported in fertilizer products?**

Yes. The standard reporting procedure for nutrient recommendations are: N for nitrogen, P₂O₅ for phosphate, K₂O for potassium, S for sulphur, B for boron, Cu for copper, Mn for manganese, Fe for iron, Zn for zinc, and Cl for chloride. However, the reporting procedure for available soil nutrients varies from laboratory to laboratory; normally P is reported for phosphorus (not P₂O₅) and K for potassium (not K₂O) which are the product listings on the fertilizer bags. Your soil test report will indicate the method of reporting used.

**Are the predicted yield increase curves and the data obtained from soil testing research relevant to my area?**

Soil testing databases are obtained from experiments conducted by provincial, federal, university and private sector scientists. The databases traditionally have been developed on a soil zone basis, but many soil testing laboratories refine the databases to individual soil types. In all cases, the databases are based on average conditions. Their adoption to fertilizer recommendations for a particular field is derived by using a wide range of “tools” assisted by highly refined computer software programs, together with a good dose of common sense and experience.

**Can nutrient recommendations be altered if a crop is being grown on legume stubble?**

Yes, but one must make sure that this alteration has not already been included by the soil testing laboratory on the basis of the previous year’s crop. A number of “credits” for fallow and legumes can be assigned but they should be looked at as guidelines rather than as recommendations. In general, 5-10 lb N/acre can be credited for every 1000 lb of legume seed produced and 20-25 lb N/acre when legumes are used as green manure.

**Does the potassium soil test accurately predict when potassium fertilizer should be used?**

The potassium soil test, like that for phosphorus, and other nutrients provides an index of potassium availability in the soil. This index is meaningful only when it is correlated to plant growth. Existing correlations for common potassium soil tests would suggest that generally there is little reason to question their accuracy of predicting plant requirements. However, there are cases where responses to potassium may be observed even on soils with high potassium levels. This is normally associated with cool springs and the limited ability of potassium to move by diffusion from the soil to plant roots. This is directly associated with environmental conditions and any test that is carried out under controlled laboratory
conditions would not be able to predict it. Some laboratories offer guidelines to that effect and warn the producer of this anticipated response.

**My soil test indicates high soil nitrogen, should I still apply some with the crop?**

In principle, no. In practice, a zero rate should be looked at as a guideline rather than a recommendation. Depending on the distribution of nitrogen in the soil profile, the moisture conditions and actual level of nitrate-nitrogen in the soil, a small amount (say 10 lb N/acre) may be applied to ensure proper establishment of a crop. Often, artifacts are created by the sampling scheme followed. Including the low spots from a field in the sample, especially where salts (and nitrate) are accumulated, can skew the true nitrogen fertility status of the “good” parts of the field thereby resulting in higher nitrogen soil test levels and therefore lower or zero nitrogen recommendations than is warranted.

**Does micronutrient availability influence crop response to macronutrients?**

Micronutrient deficiencies can have a serious impact on the response of crops to macronutrients (e.g., N, K, P and S). A soil test of the 0-6 inch depth can provide a reliable guideline for micronutrient deficiencies. In some cases, high concentrations of a micronutrient below 6 inches may mask a serious deficiency in the surface soil. A plant tissue test is currently the most reliable method for determining a micronutrient deficiency.

**My neighbors say the nitrogen levels can vary from 20 to 150 lbs of nitrogen (2 foot depth) within a single field. How accurate are these soil tests?**

It is true that the range of soil nitrate within a field (or between fields) can be considerable. However, by eliminating areas of the field that are obviously not typical of the whole field (low spots, hill tops, etc.), this range can be greatly reduced, and a reasonably representative sample can be obtained. If there are large areas of obviously different soil types, each soil type should be sampled separately. You should take at least one separate, composite soil sample for about every 80 acres. Remember also that a nitrogen soil test is only as accurate as the care put into taking and drying the soil sample.
Timing

When is the best time to fertilize non-irrigated small grains: fall or spring?

The several advantages of fall application (such as better distribution of labor for the farmer and usually lower prices of fertilizers in fall) make fall application a viable alternative to spring application. Time of application is primarily of concern for nitrogen fertilizer because phosphorus should be seed-placed whenever possible. Phosphorus and potassium should be applied in the spring. Spring application of nitrogen has lower risk of leaching, denitrification, and losses in runoff. One also knows more about soil water conditions in the spring, allowing more accurate prediction of crop needs. The major advantage of fall application is spreading of work load. Even though some precautions are necessary, fall application is acceptable. In both fall and spring, volatilization and denitrification of surface-applied nitrogen will be reduced if the soil surface temperature is below 5 to 10°C.

In northern and central Alberta, grain yields of barley are substantially lower when urea is broadcast and soil-incorporated in the fall, compared to similarly applied urea in the spring. When nitrogen is applied in the fall, nitrate fertilizer sources are generally less effective than ammonium sources. The reduced effectiveness of fall-applied nitrogen is due to over-winter mineral nitrogen losses, mostly by denitrification (biological conversion of nitrate into nitrogen gas under anaerobic conditions) and probably by leaching of nitrate nitrogen in coarse textured soils. Spring application, on the other hand, has lower risk of leaching and denitrification losses because the crop is actively removing nitrogen.

Ammonium-based fertilizers when incorporated into the soil are converted to nitrate, and are therefore susceptible to losses from soil. The rate of formation of nitrate from urea applied in the fall is slowed somewhat by banding the fertilizer in the soil. The effect is further slowed when this fertilizer is applied in late fall when soil temperature is below 10°C. For maximum yield response from fall applications, nitrogen fertilizers should be applied in late fall rather than in early fall, and should be banded in widely spaced rows (say 30 cm apart).

How late in the spring can I delay nitrogen application to small grains?

The best rule is to apply nitrogen in the spring as early as possible. If for some reason preplant application cannot be made, nitrogen can be applied (less effectively) up to the five-leaf stage for small grains and ammonium nitrate is the preferred source of nitrogen. Adequate rainfall or irrigation is necessary to move late applied nitrogen into the root zone.

Why is it so important to make spring application of nitrogen early?

Cereal grains take up most of their nitrogen early in the growth cycle: that is, during the vegetative stages. This helps establish the number of tillers, and therefore heads per acre, which is the major determinant of yield in cereals. Nitrogen must be available when it is needed most and it is not possible to
make it up later. Early application is not as critical for long-season (warm season) crops such as corn or sugar beets.

I want to broadcast urea impregnated with treflan in the fall but I was told I might lose too much nitrogen compared to banding. Is this true?

The convenience, and field efficiency, of fall applications of urea impregnated with treflan could offset differences in nitrogen loss between broadcast and banding. If conditions favour large losses, spring application of urea-treflan is an alternative. The relative efficiencies of nitrogen application in fall, spring, broadcast and band application for various moisture conditions in western Canada are shown in the following table.

The relative effectiveness of methods and time of nitrogen application for increasing crop yield

<table>
<thead>
<tr>
<th>Method and time of application</th>
<th>Soil climatic categories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry⁺</td>
</tr>
<tr>
<td>Spring broadcast and incorporated</td>
<td>100</td>
</tr>
<tr>
<td>Spring banded</td>
<td>120</td>
</tr>
<tr>
<td>Fall broadcast and incorporated</td>
<td>90</td>
</tr>
<tr>
<td>Fall banded</td>
<td>120</td>
</tr>
</tbody>
</table>

⁺ Although spring and fall banded nitrogen were equally effective in research trials, fall banding may be more practical under farm conditions. The extra tillage associated with spring banding may dry the seedbed and reduce yields.

+++ In research trials conducted in the higher rainfall areas, spring broadcast nitrogen was well incorporated and seeding and packing completed within a short period of time. Under farm conditions, shallow incorporation or loss of seedbed moisture resulting from deeper incorporation may cause spring broadcast to be somewhat less effective than shown here.
Placement

For additional information see recent publication Saskatchewan Advisory Council on Soils entitled “Guidelines for safe rates of fertilizer applied with the seed”.

If I increase the seed row N, should I also increase the rate of phosphorus fertilizer to compensate for the delayed maturity that may result? If so, can the seed row tolerate the additional phosphorus?

There is no need to put on additional phosphorus. All you are doing is placing a larger portion of the fertilizer requirements with the seed, but you are not over-fertilizing with N. Delayed maturity due to nitrogen would only occur when nitrogen is applied at much larger than recommended rates and if the water reserves are present in the soil to extend crop growth. The likelihood of this occurring in the prairies is rare, except in the Black and Grey soil zone.

Is dual application of N and P (also called “double shooting”), an acceptable method for applying fertilizer P for cereal grains?

In western Canada placement of fertilizer phosphorus with the seed maximizes both efficiency of fertilizer uptake and yield. However, with the development of banding equipment, many farmers prefer to apply both N and P prior to the seeding operations and researchers have confirmed that this method of supplying the crop with phosphorus can be quite effective. This approach tends to be more effective on soils that have a significant history (e.g., 20-30 years) of previous fertilizer phosphorus applications. On soils that have recently been broken, under cool conditions, and on soils that are very responsive to P, all, or at least some of the phosphorus should be applied in the seedrow to ensure that the early phosphorus requirements of the crop are satisfied.

Is banding phosphorus alone, prior to seeding, an acceptable practice?

No. Placing phosphorus fertilizer more than 1.5 inches away from the seedrow will significantly reduce its contribution to the growth of the current crop. Consequently, banding phosphorus prior to seeding (e.g., for a crop grown on summerfallow) is not recommended. Banding N and P in separate operations is also not recommended. The required N and P should be placed in a common band to ensure that adequate crop recovery of the phosphorus is achieved. Note as well that separate banding operations require labour and add to costs.

Can I put all my fertilizer requirements with the seed if the fertilizer is spread over 5-6 inches?

The answer is generally yes; however, remember a number of factors (i.e., amount of fertilizer required,
soil type and conditions, crop type and seeding equipment to be used) need to be considered to determine the “safe” rate for seedrow application for each given situation. The “safe” rate will also vary from year to year depending on seedbed moisture status. Exceeding the “safe” rate can result in serious crop loss. A wider degree of seed and fertilizer scattering will allow more fertilizer to be placed in this manner. When the seed is scattered 5-6", approximately 45% of the total seedbed is utilized (i.e., assuming an air seeder with a 12” shank spacing is being utilized to place the seed). Using this configuration, on a clay loam soil, 200 lbs/ac of 34-17-0 can be applied for a cereal crop with good results, if seedbed moisture is good. The rate would have to be decreased for coarser textured (i.e., sandier) soils, low organic matter soils, drier seedbeds, oilseed crops, or if free lime or salts are present in portions of the field. It is critical that rates of seed placed fertilizer be increased gradually to gain experience under your specific field conditions with this approach to fertilizer application. (See Tables below.)

**Permissible rates of urea-N seed placed for cereal grains as affected by soil texture, seed opener, and row spacing.**

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Opener</th>
<th>Disk or Knife (1&quot; spread)</th>
<th>Spoon or Hope (2&quot; spread)</th>
<th>Spoon or Hope (4&quot; - 5&quot; spread)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Row Spacing 6”, 9”,</td>
<td>Row Spacing 6”, 9”, 12”</td>
<td>Row Spacing 6”, 9”, 12”</td>
<td>Row Spacing 6”, 9”, 12”</td>
</tr>
<tr>
<td>Light (Sandy loam)</td>
<td>Disk or Knife (1&quot; spread)</td>
<td>20 15 10</td>
<td>30 20 15</td>
<td>35 30 20</td>
</tr>
<tr>
<td></td>
<td>Spoon or Hope (2&quot; spread)</td>
<td>30 20 15</td>
<td>40 30 20</td>
<td>55 40 30</td>
</tr>
<tr>
<td>Medium (loam-clay loam)</td>
<td>Spoon or Hope (4&quot; - 5&quot; spread)</td>
<td>35 30 20</td>
<td>50 35 25</td>
<td>65 50 35</td>
</tr>
<tr>
<td>Heavy (clay - heavy clay)</td>
<td>Spoon or Hope (4&quot; - 5&quot; spread)</td>
<td>15 10 5</td>
<td>35 25 20</td>
<td>45 30 25</td>
</tr>
</tbody>
</table>

* Data prepared by the Saskatchewan Advisory Fertilizer Council.
* For ammonium nitrate 34-0-0, rates can be increased by 25%.
* Where seedbed moisture is low, or when weather is conducive to fast drying of the seedbed (hot and windy), reduce rates shown in the table by at least 50%.

**Permissible rates of urea-N seed placed for canola and flax as affected by soil texture, seed opener, and row spacing.**

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Opener</th>
<th>Disk or Knife (1&quot; spread)</th>
<th>Spoon or Hope (2&quot; spread)</th>
<th>Spoon or Hope (4&quot; - 5&quot; spread)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Row Spacing 6”, 9”,</td>
<td>Row Spacing 6”, 9”, 12”</td>
<td>Row Spacing 6”, 9”, 12”</td>
<td>Row Spacing 6”, 9”, 12”</td>
</tr>
<tr>
<td>Light (Sandy loam)</td>
<td>Disk or Knife (1&quot; spread)</td>
<td>5 0 0</td>
<td>20 15 10</td>
<td>30 20 15</td>
</tr>
<tr>
<td></td>
<td>Spoon or Hope (2&quot; spread)</td>
<td>10 5 5</td>
<td>25 20 15</td>
<td>35 25 20</td>
</tr>
<tr>
<td>Medium (loam-clay loam)</td>
<td>Spoon or Hope (4&quot; - 5&quot; spread)</td>
<td>15 10 5</td>
<td>35 25 20</td>
<td>45 30 25</td>
</tr>
</tbody>
</table>

* Data prepared by the Saskatchewan Advisory Fertilizer Council.
* For seed placement of ammonium nitrate flax 34-0-0, rates can be increased by 25%. For canola 34-0-0 is as likely to damage seedlings as urea 46-0-0 is.
* Where seedbed moisture is low, or when weather is conducive to fast drying of the seedbed (hot and windy), reduce rates shown in the table by at least 50%.
Permissible rates of phosphate (P₂O₅) seed placed for different crops. Rates are based on good to excellent soil moisture, 6" to 7" row spacing, and disk or knife openers with a 1" fertilizer spread.

<table>
<thead>
<tr>
<th>Crop</th>
<th>P₂O₅ (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canola</td>
<td>20</td>
</tr>
<tr>
<td>Flax</td>
<td>20</td>
</tr>
<tr>
<td>Faba bean</td>
<td>40</td>
</tr>
<tr>
<td>Lentil</td>
<td>20</td>
</tr>
<tr>
<td>Pea</td>
<td>15</td>
</tr>
</tbody>
</table>

* Data prepared by the Saskatchewan Advisory Fertilizer Council.
* Rates based on monoammonium phosphate (12-51-0, 12-52-0, or similar), Diammonium phosphate (18-46-0 or similar) is much more toxic to the seeds and should be used with caution.

How much fertilizer can I apply with the seed for wheat and canola?

For cereals, the total amount of fertilizer you place with the seed should not exceed 170 lb/ac. Not more than 40 lb/ac of N as ammonium nitrate (34-0-0), and not more than 25 lb N/ac as urea (46-0-0) should be seed placed. In contrast, no more than 30-35 lb/ac of monoammonium phosphate (11-55-0) should be applied with the seed of canola. These recommendations have been developed for narrow row seed placement, such as for double disc drills. Higher rates may be applied when the seeding implement spreads the seed row wider (e.g., air seeders) (See Tables above.)

If I apply liquid nitrogen with the seed, can I apply higher rates of nitrogen than if I use granular?

The maximum rate of nitrogen as urea and ammonium nitrate that can be safely placed in the seedrow under various conditions is shown in the tables above. Liquid nitrogen (28-0-0) is made up from equal amounts of urea (46-0-0) and ammonium nitrate (34-0-0), the two main granular nitrogen fertilizers. Therefore, the maximum rate of 28-0-0 that can be safely placed in the seedrow is intermediate between urea and ammonium nitrate. Note also that the amount of water applied with the liquid fertilizer is small and therefore has no effect on seedling damage.

Is there equipment available that I can use on an air seeder to apply seed, dry fertilizer and anhydrous ammonia in one pass? What rates can I use?

The application of anhydrous ammonia at the time of seeding is a newly emerging technology in which
there is a great deal of interest among farmers who own air seeders. Various types of openers are being evaluated and several appear to be very promising. In some cases, 100 lbs N/ac have been applied at the time of seeding without any apparent harm to the establishment of a cereal crop. A successful opener should maintain a significant soil barrier between the seed and the anhydrous ammonia while effectively preventing the ammonia gas from escaping to the atmosphere.

**How tight a band do I need for maximum fertilizer N efficiency?**

Compact, concentrated bands help to slow the conversion of \( \text{NH}_4^- \text{-N} \) to \( \text{NO}_3^- \text{-N} \). The latter form of nitrogen is more vulnerable to over-winter losses. Therefore, a delay in conversion is desirable, particularly on poorly drained soils. For fall application, the band should be kept as narrow as possible. A wider spacing between bands is also helpful since more fertilizer is concentrated within each band. On poorly drained soils, delaying the application until late fall also helps to reduce losses. On well-drained soils and for farms located in drier regions, application date and band configuration is less critical. Similarly, concentration of fertilizer is not critical with spring applied bands. In fact, in the spring of the year the presence of a high rate of highly concentrated nitrogen in a dual N-P band can interfere with early crop uptake of phosphorus fertilizer.

**Will foliar feeding improve small grain yields?**

Foliar feeding is not a practical means of applying macronutrients (N, P, K, and S) to a crop. Some crops suffering from a micronutrient deficiency can be salvaged by a series of foliar applications but, in most cases, soil application is more practical and cost effective. Irrigation farmers can apply fertilizer nutrients through the irrigation water. However, the bulk of the nutrients are washed off the leaves and enter the plant through the root system rather than through the leaves.

**Won’t fertilization and foliar feeding burn the vegetation? How much will this hurt yield?**

If the level of nutrients applied is excessive, the fertilizer can burn the vegetation. Whether this hurts yields depends on how much was applied, how much damage occurred and whether the crop was severely deficient (i.e., did the yield response to the applied fertilizer more than compensate for the damage). Dribble application of the liquid fertilizer penetrates the canopy and has no negative effect on the vegetation.

**What are the guidelines for top-dressing nitrogen on cereals, oilseeds and forages?**

For annually seeded crops, some type of band application (i.e., preplant, seedrow, sideband or midrow) is recommended since broadcast applications can be significantly less effective. If at least one-half of the required nitrogen is band applied prior to the growing season, reasonably good results are possible if the remainder is top-dressed, providing the nitrogen fertilizer is applied no later than the tillering stage and sufficient rain is received soon after the application to move the top-dressed nitrogen into the rooting zone.
For forage crops, fertilizer is normally top-dressed. Best results are achieved with either a late fall or an early spring application. Researchers have demonstrated that yield response to nitrogen on grass forages can be increased by 20-50% if the fertilizer is placed below the soil surface with a disc-band opener.

For forage crop seed production, some grasses (rye grasses) respond best to nitrogen fertilizer applied after seed harvest in July or August.

Is there any sense in top dressing nitrogen on crops in the Dark Brown and Brown soil zones?

In the more humid areas, such as the Black soil zone, top dress nitrogen 2-3 weeks after seeding can be quite effective. This is a common practice in more humid parts of the world where fertilizer nitrogen applications are quite frequently split. However, under the semi-arid conditions prevailing in the Brown and Dark Brown soils, post-emergent application of nitrogen is generally not recommended.

Is side-banding an option for grain crops?

Yes. Side-banding (placing the fertilizer slightly to the side and below the seed) is a viable option, especially for the moister areas of the prairies and for crops such as flax and corn. Side-banding permits the placement of higher rates of fertilizer than is possible with seed-placement, while still allowing the fertilizer to be placed close to the seed.

Farmers in the drier Dark Brown and Brown soil zones, especially those seeding winter crops on stubble land, should be careful because side-banding tends to enhance drying of the soil. Implements capable of side-banding open a large furrow that may lead to a faster drying of the soil than does equipment with a smaller furrow opener. In these drier areas, most nutrient requirements can generally be placed with the seed.

If I am side-banding, can I reduce nutrient additions and to what extent?

Side-banding is usually more efficient method of putting on fertilizer N, P and K than broadcast applications. Phosphate and potassium applications should be approximately doubled if the fertilizer is broadcast rather than banded (depending on the soil test levels and environmental conditions). Banded applications of nitrogen are generally 10 to 20% more efficient than broadcast applications. This holds true whether the band is a side-band, a deep band, or a seed-placed band, as long as there is no damage from excess seed-placed fertilizer. Side-banded P is more efficiently used than dual-banded P, particularly for crops such as flax where root development in the spring is slow, or under cool soil conditions which will restrict root growth and nutrient mobility.

Does side-banding reduce nutrient availability to weeds and reduce weed growth?

Band applications in general tend to reduce the availability of fertilizer to some weeds, particularly
shallow-rooted weeds such as green foxtail, as compared to broadcast fertilizer applications. This gives the crop a competitive edge. Side-banded fertilizer will be positionally more available to the growing crop than to most of the weed population, so this should give the crop an additional competitive advantage, particularly with such relatively immobile nutrients as P.

Are there differences in crop use or in the hazard between types of nitrogen fertilizer?

Fertilizer nitrogen sources are generally equally effective, if they are applied in the recommended manner. There are, however, situations in which each of the types of fertilizer nitrogen has an advantage. For example, if higher rates of seedrow nitrogen are to be applied, the damage potential for seedlings would increase in the order ammonium nitrate < urea ammonium nitrate < urea.

What is meant by “nesting”?

Nesting refers to placing the fertilizer in discrete pockets or nests. As with banding, this reduces the contact between the soil and the fertilizer, thus reducing potential losses. The use of spoke wheel injectors or large fertilizer prills are two methods of achieving this type of placement. This approach to fertilizer application may prove effective in applying fertilizer under zero tillage. Research on this method of fertilizer application is still in the development stages in western Canada.

What is the potential for midrow banding as far as fertilizer efficiency is concerned?

Midrow banding can be very effective for nitrogen fertilization but not for P. It has the advantages of other banding systems and can be utilized in a one-pass seeding and fertilizing system, thereby reducing the number of operations required. The fertilizer is placed an equal distance from each seedrow, which should lead to more even nutrition of the stand. Problems may occur with the equipment involved, in terms of draft requirement, soil disturbance, and trash clearance, particularly in a no tillage system. While quite effective, seeding equipment with this type of banding capability tends to be more expensive than alternative types of seeding equipment.
Forage Crops

I am planting a new stand of perennial forage. What level of fertility should there be prior to planting?

This depends on the type of forage, i.e., legume, grass or grass-legume. In all cases, ensure that there is an adequate supply of all major nutrients N, P, K, S; in particular, high levels of P and K are required since these nutrients are immobile.

Before seeding alfalfa is it best to band P and even some N?

Phosphorus fertilizers should be banded in alfalfa fields prior to seeding or side banded at the time of seeding at rates based on a soil test. Nitrogen is not required but alfalfa seed must be properly inoculated with the appropriate nitrogen fixing bacteria prior to seeding so as to ensure adequate nitrogen fixation.

Is there an advantage to applying fertilizer nitrogen when establishing alfalfa?

No. Not unless there is need to push for production in the first season, in which case a starter amount of N may speed development in nitrogen deficient soils.

What should I put on my established pasture?

Established pastures should be fertilized according to the species composition. If the stand contains more than 25% alfalfa, fertilize as for a pure alfalfa stand. If less than 25% alfalfa, fertilize as for a pure grass stand. Fertilize according to soil test recommendation. Phosphorus and potassium may be required in either grass or alfalfa-based pastures. Nitrogen does not normally give an increase in yield in alfalfa-based pastures.

How should I fertilize a nurse crop when establishing a legume or grass forage stand?

There are no nurse crops. Companion crops tend to compete with the forage crop for light, nutrients and moisture. Generally, it is best to avoid using companion crops. If one is grown, it should be sown at about half the normal rate and removed as soon as possible. Fertilizer management should be designed to assist the forage crop, not the companion crop. Perhaps use of the full base rate for the forage plus a moderate rate for the companion crop would be best.

Is fertilizer beneficial on native grass stands? If so, what is the best way to apply it?

Nitrogen is the main nutrient generally required. Yield increases per unit of fertilizer nitrogen are
markedly influenced by precipitation and is very inconsistent during dry years. With adequate yield, stocking rates can be increased by 300% and additional benefits include a longer grazing season and improved forage palatability. Ammonium nitrate remains the preferred nitrogen source because losses from it are significantly lower than for urea-based nitrogen fertilizers. The fertilizer is best applied in the early spring on the unfrozen soil with late fall application on cool unfrozen soil a close second choice.

**How should I apply phosphorus to my existing perennial forages?**

Phosphorus can be broadcast on perennial forages with very good results on phosphorus deficient soils in the more humid regions of the prairies. Alfalfa, for example, has a root system with many roots close to the soil surface and thus can effectively utilize broadcast applications of phosphorus. Grasses can also use broadcasted phosphorus. Applying the phosphorus in fall usually is more effective on first cut of forage the following year than adding phosphorus in the spring. Single-large applications of phosphorus, prior to forage establishment can provide phosphorus for at least the first few years of forage production but is less effective than annual applications.

**Is it true that it is highly unlikely that my alfalfa or alfalfa-grass hay stand would respond to potassium?**

Alfalfa stands are more likely to respond to K fertilization than are cereal crops because large quantities of K are removed from the system with the forage. For example, 5 tons/acre of alfalfa remove 300 lb/ac K<sub>2</sub>O from the soil while 3 tons/acre of grass removes approximately 100 lb/ac K<sub>2</sub>O. Good responses of alfalfa to K fertilizer have been observed even on Black soils that have tested relatively high in K. Coarse-textured Gray soils are chronically K deficient and forages grown on these soils usually require K fertilization. Older stands of alfalfa are more susceptible to K deficiency than younger stands. Proper K management of alfalfa will improve forage quality, yield, winter survival and stand longevity. In a mixed grass-alfalfa stand, adequate K fertility is required to ensure that the alfalfa competes adequately with the grass to maintain a proper species balance.

**What is the most effective source of sulphur for alfalfa and clover?**

Ammonium sulphate is most effective in the year of application. Gypsum and finely divided elemental sulphur are good slow release fertilizers, but don’t expect an immediate response even though your soil tests suggest that this may occur. Soil tests, plant tissue analysis, and N/S ratios all play a significant indicator role in defining sulphur deficient forage crops. Contact your nearest soil testing lab for further information on this important topic.

**Is it better to fertilize grass rather than break it up?**

Yes, it is better to increase production of grasses by fertilizing as compared to breaking, except where new or different plant types are needed in the sward, i.e., the field should be broken if you plan to start alfalfa together with the existing grasses.
Economics

I have a limited amount of money. Where is the best place to cut back on fertilizer?

Fertilizer is not a luxury expense item but an input capable of producing high returns. Generally, when money is limited for fertilizer purchases, net earnings will be greatest if you reduce the rate of application over the entire cropped area, as compared to fertilizing a portion of the farm at the full recommended rate and leaving the rest unfertilized.

However, if your banker is still not convinced, then cut back more on land where production is limited by factors other than fertility, e.g., saline, depressional, or poor physical condition in the field. Such land does not return as much per dollar invested in fertilizer. It is important to have a soil test to assure accurate recommendations, because land that has been fertilized or manured for several years will show a nutrient buildup. Thus the fertilizer requirement maybe less than has been routinely used.

Are fertilizer additions more economic on knolls or on moist lower slopes?

On the prairies, research has shown that fertilizer additions on rolling topography will increase crop yield and moisture use efficiency at all slope positions. Larger yields generally occur on lower slopes than on knolls but yield increases in response to fertilizer was only higher on lower slopes that were seeded on summerfallow; on stubble, yield increases were higher for knolls (see table below). Varying the rates of fertilizer according to landscape position and yield potential will help to match fertilizer applications to crop requirements.

Yield (bu/ac) of spring wheat as affected by fertilization of stubble and fallow fields in rolling landscapes in Saskatchewan.

<table>
<thead>
<tr>
<th>Slope Position</th>
<th>Control</th>
<th>Fertilized</th>
<th>Yield Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Stubble</td>
<td></td>
</tr>
<tr>
<td>Knoll</td>
<td>18</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>Upper</td>
<td>20</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Lower</td>
<td>19</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Depression</td>
<td>25</td>
<td>29</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fallow</td>
<td></td>
</tr>
<tr>
<td>Knoll</td>
<td>21</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Upper</td>
<td>23</td>
<td>28</td>
<td>5</td>
</tr>
<tr>
<td>Lower</td>
<td>22</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>Depression</td>
<td>28</td>
<td>35</td>
<td>7</td>
</tr>
</tbody>
</table>

Can I afford to seed and fertilize stubble under current adverse market conditions?

Research has clearly shown that where producers have followed good management by using adequate fertilizer inputs based on soil tests, and have kept summerfallow to a minimum, the N and P supplying
power of the soil will be enhanced. Adequate fertilizer inputs are required each year and even under the current depressed market conditions, fertilization will usually return dividends. It is more expensive to “build-up” your soil nutritional status than to maintain it at an adequate level.

The soil test recommendations I have received appear much too high. Will I make any money applying these rates?

There is no guarantee that by following the soil test recommendations you will make a profit every year, because of uncertainty in weather, costs and prices. Soil test recommendations are based on the probability of getting an economic return to fertilizer applications. While the cut-off varies from lab to lab, in general, soil test labs recommend application of fertilizers until a $1.00 to $1.50 return results for the last $1.00 invested in fertilizers. You can generally expect a significant economic return if you follow the soil test recommendations, unless other management soil factors restrict yields.
How is nitrogen fixation by legumes affected by fertilizer N and P levels?

Properly-inoculated legumes are capable of fixing nitrogen from the atmosphere, therefore legumes such as peas seldom require fertilizer N. Phosphorus should be applied according to soil test recommendations to ensure early root development. A low rate of “starter N” may encourage early growth before root nodule development and nitrogen fixation is fully advanced. The best fertilizer for legumes is monoammonium phosphate (12-51-0) because it provides starter N and high P.

We hear a lot these days about the biological approach to soil fertility. Please comment.

The biological approach to soil fertility is in its infancy, partly because of our limited understanding and knowledge of soil microbial ecology and factors influencing plant root growth. The commercial microbial products which are available today include legume inoculants (rhizobia bacteria) which can result in the fixation of over 100 lb/ac N. Phosphorus-solubilizing fungi and biological control agents are also just beginning to have an important impact. The eventual success of microorganisms as agronomic inputs to enhance crop production will depend on their performance under field conditions, the cost effectiveness, and ease of handling.

What about Provide; wouldn’t a farmer be better off to spend the dollars on phosphorus fertilizer?

Provide is Dow-Elanco’s trade name for a P-solubilizing, naturally occurring fungus (Penicilliumbilaii). Provide is registered under the fertilizers act (administered by Agriculture Canada) for wheat, canola, lentil and peas. Registration implies that Provide has been shown, after rigorous agronomic and statistical test procedures, to meet the product’s claims. For instance, the Provide claim for wheat is that, when a phosphorus yield response is anticipated based on soil test predictions, Provide can replace up to 10lb/ac of fertilizer P₂O₅. The decision to use Provide, like any other input decision, should be based on the farmer’s estimate of the cost / benefit of the product relative to the anticipated but more difficult to measure “agronomic” benefits. Farmers make these decisions every spring: Do I apply phosphorus to obtain the well-known “pop-up” effect? Well, that depends if it will be a cool, wet spring and who can predict that? Do I seed-coat with Vitavax? Well, that depends on the probability of infestation by soil-borne and seed-borne pathogens. Ultimately, the decision is based on a mixture of experience and economics. Like every new product, farmers who are interested in assessing Provide should do so with a strip test for comparison.
Environment

Is nitrogen from decaying organic matter used more efficiently than fertilizer N?

Available nitrogen is the same whether it comes from decaying residues or from fertilizers, or from rain. The nitrogen released from decaying organic matter through microbial action (i.e., mineralization) is a relatively slow and unpredictable process—dependent on environmental conditions. With nitrogen fertilizer, proper timing, source, and method of fertilizer nitrogen placement give farmers better control of when the nitrogen will be made available to the growing crop. Nitrogen released from organic sources late in the growing season may be subject to losses from the system by leaching or gaseous means.

Are phosphorus losses from farms a significant environmental problem on the prairies?

They can be. Any time soil is lost from a farm because of erosion by wind and water it carries phosphorus. Some phosphorus can also be lost in sediment via surface runoff into rivers, lakes and dugouts. Leaching losses of phosphorus are not a major problem because phosphorus strongly binds with other soil compounds, making it fairly immobile in the soil. Where manure is applied to land, some organic phosphorus may be lost by leaching and runoff from fields. Good soil conservation practices can virtually eliminate phosphorus losses from farmland.

What does long term research tell us about nitrate losses where "best management practices" have been used consistently for a number of years?

"Best management practices" will likely involve regular use of fertilizers, legumes and/or manures. In time, these will increase the nitrogen supplying power of the soil. This potential for increasing mineral nitrogen production also means an increased potential for nitrogen losses to occur. However, this is unlikely to occur if the land is cropped annually, as it should be if "good management practices" are adopted. Long term research shows that practices are available which can reduce nitrate losses via leaching, denitrification and volatilization. These methods involve placement techniques which help keep applied nitrogen in an ammonium form until it is needed by the growing crop. Such placement techniques include banding, spoke injection, and nesting. Proper timing of fertilizer nitrogen application is essential to reducing leaching losses. But most important is to determine proper nitrogen requirements by soil testing and to keep summerfallowing to a minimum.

Are organic sources of N, such as manures and legumes better for the environment than fertilizers?

There is no evidence to suggest that one nitrogen source is better for the environment than another. Long-term research in the Black soil zone shows that nitrate leaching is as possible from the use of legume green manure or hay-containing systems as it is from fertilized systems. Nitrates in groundwater can
originate from soil humus, fertilizers, manure or decaying crop residues. In fact, nitrogen from organic sources may result in greater nitrate leaching because the timing of nitrogen release may not necessarily coincide with crop requirements.

I have heard that nitrates get into the groundwater in parts of the U.S. Is this happening in western Canada?

Nitrates have been detected in wells in western Canada from point source contamination. For example, livestock wastes have caused excessive nitrate levels in some poorly constructed farm wells. Fertilizer nitrogen could also contribute nitrates to groundwater if excessive rates were used, especially in lighter textured soils. However, if nitrogen applications are based on soil test recommendations, fertilizers will rarely contribute nitrates to groundwater on the prairies except where excessive summerfallowing is practiced.

If the fertilizer use efficiency of fall applied nitrogen is lower than that of spring applied N, should I be applying nitrogen in the fall? What is the environmental significance of the lost N?

There is no question that fall applied nitrogen has a greater loss potential than nitrogen applied in the spring close to seeding. This does not apply to fall seeded crops like winter wheat or fall rye. A good rule of thumb is to fertilize the crop, not the soil! Microorganisms use nitrogen much more efficiently than do crops, so to give the crop an equal chance, apply nitrogen as close to seeding as possible.

There are various ways that nitrogen can be lost or made unavailable to the crop. These include:

- gaseous loss by volatilization (especially urea or ammonia) or denitrification (under wet conditions such as early spring)
- leaching (e.g., the risk is high when there are no plants growing)
- runoff (e.g., quick thaw in mid winter; wet spring)
- immobilization (temporary tie-up in soil microbial tissue)

With these possible avenues of loss, what then would be the advantage of applying nitrogen in the fall? This is a straight case of better economics and better control of the workload. Fertilizer prices are often lower in the fall, and spring is usually a very busy time for farmers. To reduce the losses mentioned earlier, deep banding of nitrogen and application later in the fall when soil temperatures are lower have been employed. Each producer will have to balance his possible gains in time and economics against possible losses in the efficient use of N.

Will burning of stubble or other crop residues be harmful to the soil?

Burning stubble and other crop residues, or other practices which reduce surface trash can be harmful to soil. Surface trash protects the soil against erosion loss from wind and water, conserves water in soil, and
helps build soil organic matter. Burning crop residues also releases valuable crop nutrients, which can then be readily lost through volatilization or leaching. Further, the heat generated during the burning destroys soil humus.

Does fertilizer damage the soil?

It's a common misconception that fertilizer is harmful to the soil. There is substantial evidence that fertilizer, when used properly, benefits soil quality and productivity. Long term crop rotation studies in western Canada show that judicious use of fertilizer increases crop yields, builds soil organic matter, and improves the quality of soil organic matter (i.e., mineralizable N). Increased organic residue, as a result of fertilization, also improves soil physical properties and tilth, which increase water infiltration rates. Fertilizers, legumes, or any other nitrogen source, may acidify some soils but this is not a major problem in the prairies, and may be a benefit on highly calcareous soils.

Some people believe that farmers use more commercial fertilizer than they need. What do the long term trends in fertilizer use show?

Long term trends in fertilizer consumption in western Canada show crops remove more nutrients than we replace with fertilizers. For example the average ratio of nutrient removal compared to replacement for the prairies during 1984-1989 were 1.6 for N, 1.2 for P and 9.9 for K. In other words, prairie crops remove 1.6 times more nitrogen than is replaced by fertilizer, 1.2 times more P, and almost 10 times more K. This suggests that the use of commercial fertilizer may need to be increased just to replace the nutrients exported in crops. This helps to explain the gradual decrease in soil organic matter that has been observed in prairie soils over the last 50 years.

Do fertilizers acidify the soil? If so, to what extent and how can the problem be corrected?

All fertilizers containing ammonium and sulphur can acidify the soil. Fortunately, most western Canadian soils have an alkaline pH and contain free lime which buffers the soil against acidity generated by the fertilizer. Further, many soils have high clay contents which helps them further resist changes in pH. Soils with pH less than 6, may eventually require limestone to neutralize the acidity caused by fertilization. The need for limestone can easily be monitored by regular soil testing. To date, there have been no reported instances on the prairies where liming has been required to counteract the acidity caused by fertilizers.

How do various cropping systems affect the long term supply of macronutrients in the soil?

Some groups in society suggest that we should supply more nutrients by natural means (e.g., using green manures, crop rotations, forages). Is this true?

All plants withdraw N, P, K, and S from the soil. If these nutrients are not replaced in some way the system will eventually become impoverished with regards to these nutrients. Most producers, in recognition of this fact, apply fertilizers to replace the nutrients removed in grain or feed. The only
nutrient among these four that can be economically and reliably supplied without adding fertilizers is N. Legumes can fix nitrogen from the air and thereby supply nitrogen to the soil, but they supply no P, K or S. Long term studies on Black soils and Gray soils clearly show that continued production of crops without addition of adequate macronutrients will lead inevitably to reduced yields and soil organic matter. The use of legumes (green manure and hay crops) slowed but did not stop this downward trend.