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TRENDS IN NITROGEN USE AND APPLICATION IN WESTERN CANADA[1]

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The use of fertilizer in Western Canada has been a relatively recent development. Furthermore, compared to other parts of the world, the rates of fertilizer application are quite low. Both of these facts are a reflection of the nature of the soils and yield restrictions imposed by the rather unco-operative climatic conditions that are characteristic of the Canadian prairies. Nevertheless, the use of fertilizer is critical to successful crop production in this region. Use of fertilizer has actually grown quite rapidly in the last few decades. Consequently, for many farmers, fertilizer is the major annual input cost. Therefore they are becoming increasingly interested in using fertilizer as efficiently as possible. The challenges imposed by the climate have encouraged the development of some innovative fertilizer application techniques to ensure maximum benefit is derived from the applied fertilizer.

HISTORICAL N USE

Western Canadian farmers were first being introduced to the use of fertilizer some fifty years ago. As illustrated in Figure 1, the amount of nitrogen fertilizer being applied in the early 1960's was quite small compared to the mid 1980's. The initial adoption of N fertilizer was stifled by the fact that the newly broken farm lands tended to contain sufficient amounts of nitrogen to meet modest yield goals. Prairie soils relatively rich in organic matter content in combination with cultivation resulted in rapid mineralization of relatively large amounts of readily available N. The high levels of soil N were further boosted by the widespread acceptance of the practise of summerfallowing (i.e. land deliberately kept out of production for a year as a means of increasing soil stored moisture reserves and aiding weed control). Keeping the land idle in this manner resulted in high levels of available N accumulating in the soil. This fact signficantly benefited succeeding crops and sharply reduced the need for applying commercial nitrogen fertilizer.

FERTILIZER N:P_2O_5 RATIO

The newly broken soils of the Western Canadian prairies were however quite deficient in phosphorus. Therefore the use of fertilizers with a high phosphate content was initially adopted much more rapidly than was the use of nitrogenous fertilizers. As

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illustrated in Figure 2, in the early 1960's the use of phosphate was double that of nitrogen. The use of N did not equal that of phosphate until the 1970's. At the current time, Western Canadian farmers use approximately twice as much nitrogen as phosphate. It is expected that the $N:P_2O_5$ ratio will continue to grow as yield expectations increase. The more rapid growth in use of N will also be aided by the reduced ability of prairie soils to mineralize or release N as a result of declining soil organic reserves. The growth in use of phosphate will be less dramatic due to the fact that many prairie soils have become less responsive to this nutrient due to the residual contribution of previously applied phosphate fertilizers. It is probable that the $N:P_2O_5$ ratio will exceed a value of 2.5 within the next decade.

The growth in use of potash and sulphur fertilizers has seriously lagged behind that of nitrogen and phosphate. It is expected that the rate of growth in the use of these two fertilizer the rate of growth in use of these two fertilizer nutrients will exceed that of the two major fertilizer nutrients during the next few decades. At the current time, for the Western Canadian market, the $N:P_2O_5:K_2O:S$ ratio is approximately 2.0:1.0:0.2:0.1.

RATES OF N APPLICATION

Within Europe, rates of N use on agricultural land in the early 1970's ranged from 20 kg/ha for Ireland to 180 kg/ha for Holland. Comparable figures for Denmark, Belgium, France and Germany at that time were reported to be approximately 100, 105, 45 and 85 kg/ha respectively. Current use levels are undoubtedly higher. The equivalent N use in Western Canada during that period of time was approximately 6 kg/ha of agricultural land.

For the prairie region of Western Canada in 1986, which was the year in which the highest rates of N application were achieved, the use of N per hectare of land used for annual crop production (i.e. ignoring agricultural land devoted to rangeland, forage production and that land kept idle due to summerfallowing) amounted to 33 kg/ha. If the land used for forage (tame hay) production was also included, the rate of N use declined to 30 kg/ha. It is obvious the rates of fertilizer application in Western Canada are quite modest compared to those of other developed countries. As outlined in the following sections, the severe climatic conditions typical of the Canadian and the associated crop production risks have helped to discourage the use of higher rates of fertilizer.

PRAIRIE LAND BASE

There are approximately 135 million acres (55 million hectares) of farmland in the prairie region. Of this total, about 45% is dedicated to some form of forage production and 34% has been retained as native or unimproved pasture. In other words, approximately 1/3 of the prairie agricultural land base has never been cultivated.

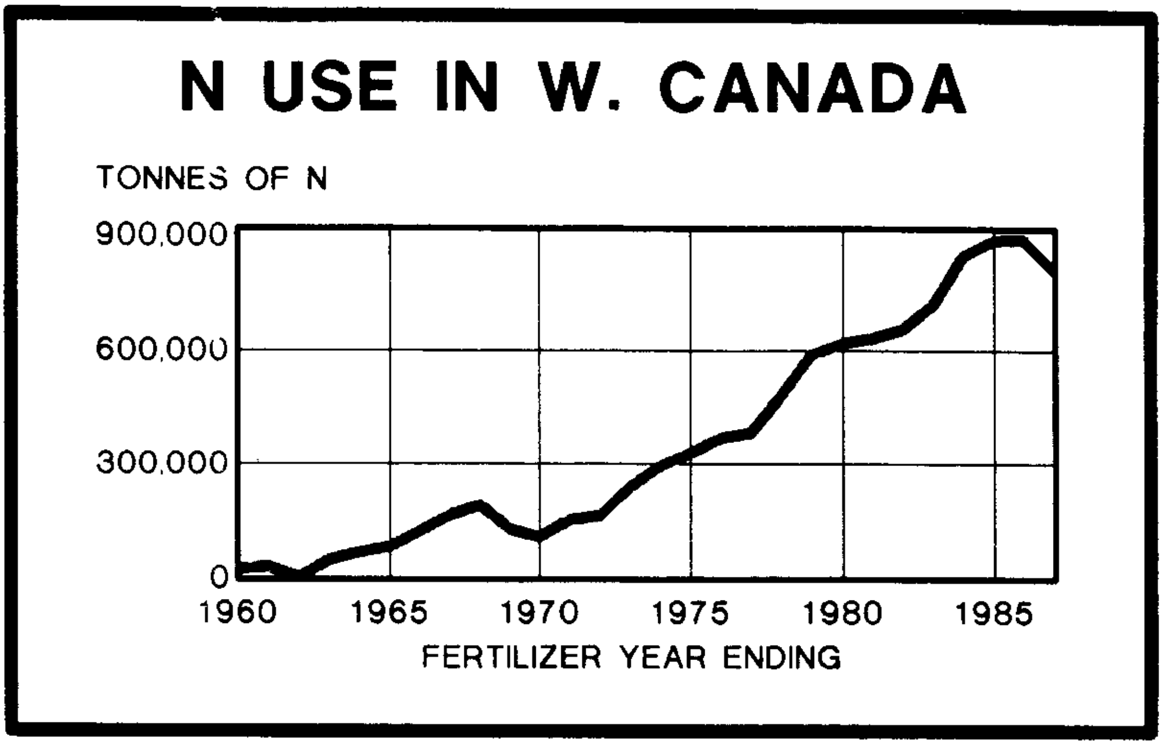


Figure 1. Historical use of fertilizer N in Western Canada during the period of 1960 to 1987 (includes all four western provinces.

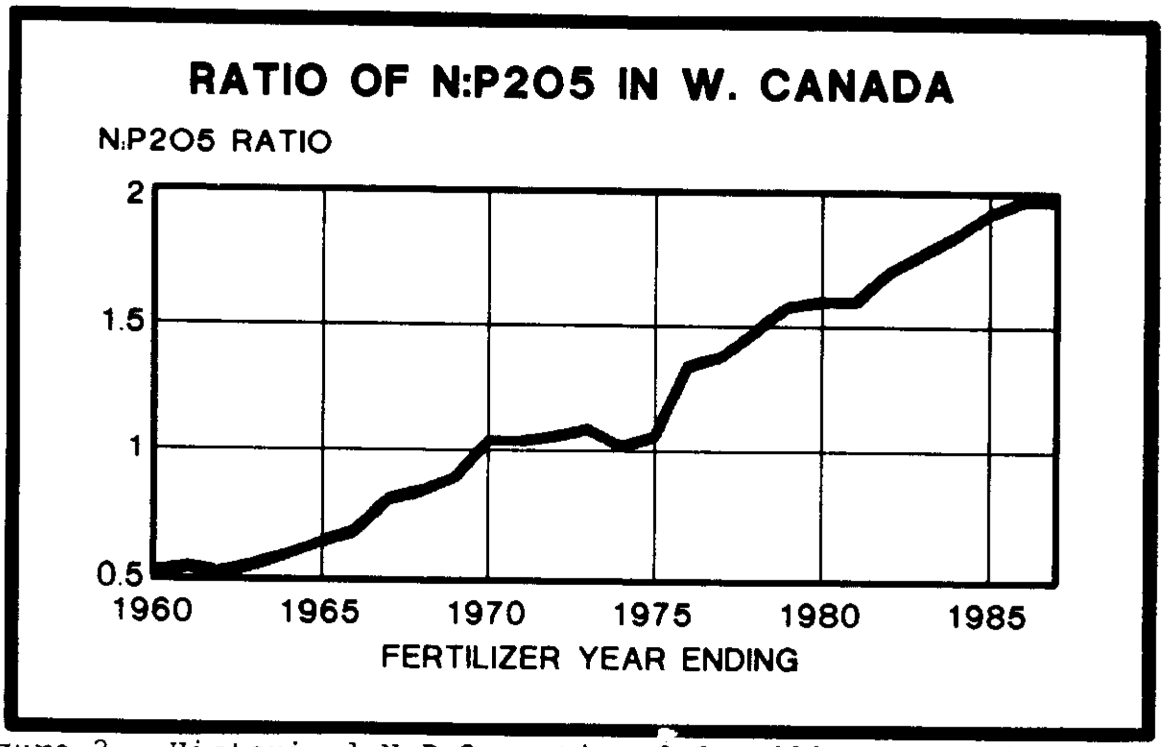


Figure 2. Historical $N:P_2O_5$ ratio of fertilizer used in Western Canada during the period of 1960 to 1987.

The distribution of the various cropping options has remained reasonably constant over the years. In 1985, approximately 42% of the annually cultivated land was used for wheat production, 22% for feed grain production and 10% for oilseed production. In 1985, fallow accounted for 25.5% of the land used for annual crop production. The amount of the annually cultivated land that was fallowed has been slowly declining from the levels (approximately 36%) maintained in the early 1960s.

PRAIRIE SOILS

The settled portion of the prairie region of Western Canada is not an area of homogenous soils and growing conditions. The main soil zones as outlined in Figure 3 are a reflection of the vegetative cover under which the soils developed. Of course, climate had a major enfluence on determining the type of vegetation that predominated in a given area.

Moving in a northeasterly direction through the core of Saskatchewan, rainfall becomes progressively higher (see Figure 4) and evaporation lower. Similar trends are evident on moving in a northwesterly direction in Alberta. The brown soils developed under a short sparse grassland cover that could be expected in a region of chronic moisture deficiency (i.e. subarid climate). These soils are generally quite shallow and contain low levels of organic matter (2-4%) in the surface layer. Significant portions of the brown soil zone are unsuitable for cropping. The dark brown soils are a little deeper and contain slightly more organic matter than the brown soils. Surrounding the brown and dark brown soils are the black soils that developed in a parkland environment consisting of tall grasses and groves of trees (primarily aspen). The slightly higher rainfall (i.e. subhumid climate) associated with this region resulted in the development of deeper soils with a higher soil organic matter in the surface layer (6-10%). The black and gray black soils are generally the most productive prairie soils. The gray or degraded soils located primarily north and northwest of the black soils developed under forest cover. Under natural conditions, these soils are overlain by a layer of decomposing leaf litter. Once these soils are broken, the relatively low organic matter content (less than 1%) and acidic nature of the cultivated layer of these eluviated soils contribute to the significant management problems that are associated with farming these soils.

The amount of land dedicated to annual crop production and fallow in the various soil zones of the prairie region is illustrated in Figure 5. The black and gray black soils account for 52% of the land in this category. Another 42% is accounted for by the brown and dark brown soil zones. In any given year, almost one-half of the brown soils and one-third of the dark brown soils are taken out of production due to summerfallowing. Only about 5% of the total annually cultivated land is accounted for by the gray soils. However, unbroken land contained within the gray soil zone represents the largest proportion of land that is still available for further agricultural development.

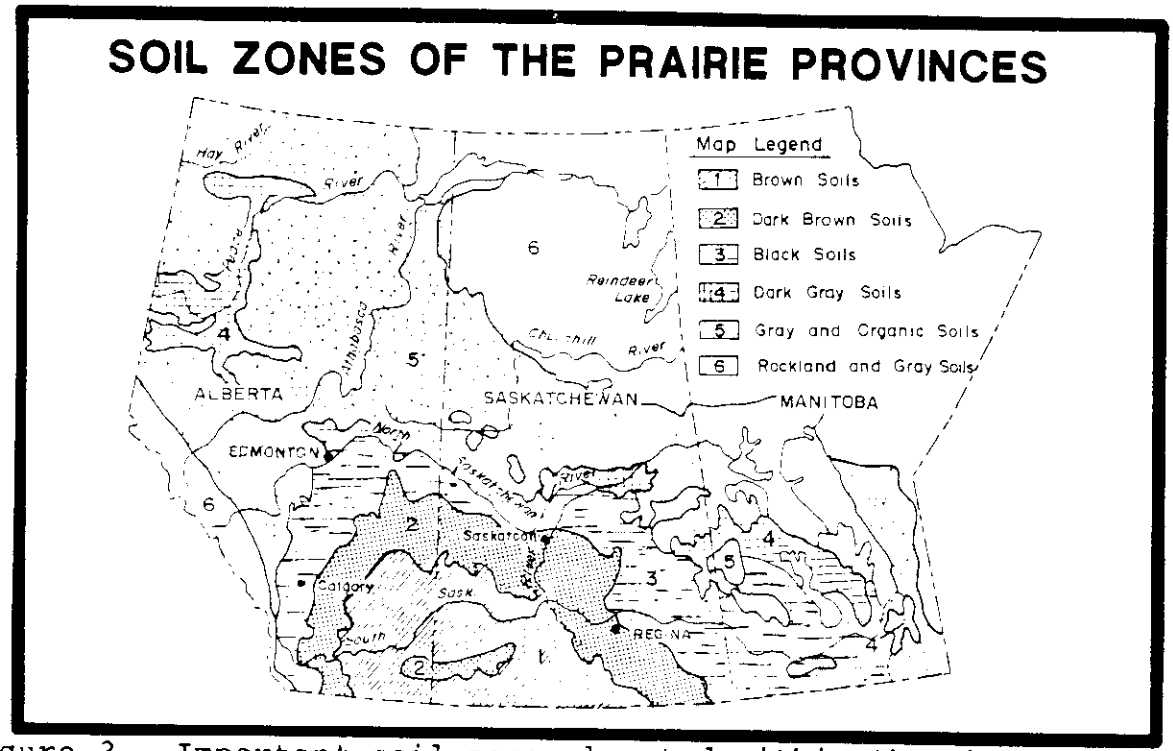


Figure 3. Important soil zones located within the three prairie provinces of Western Canada.

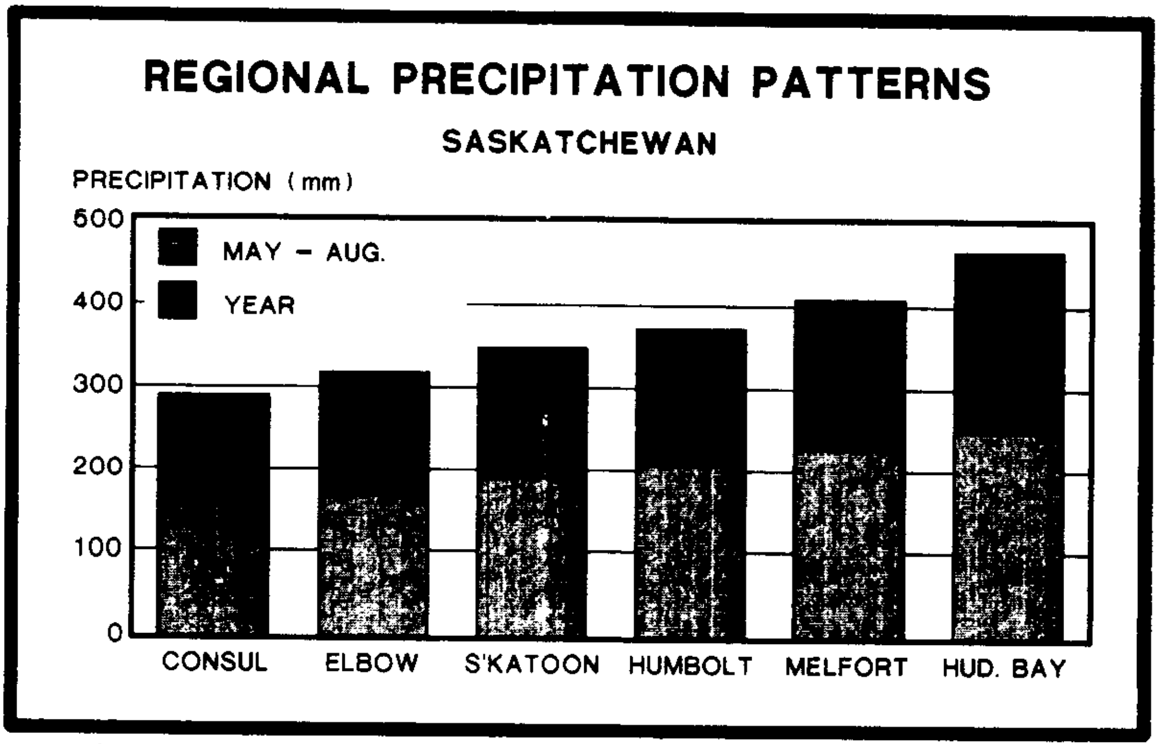


Figure 4. Regional precipitation patterns in the agricultural area of Saskatchewan on progressing in a northeasterly direction from the southwestern part of the province.

MOISTURE LIMITATIONS

On the Canadian prairies, weather has a dynamic influence on agricultural production. In common with other interior continental regions, the climate of the prairie grain producing regions is characterized by extreme and variable weather conditions. In these situations, the interaction of moisture and temperature, the key elements of climate are of utmost importance to successful crop production in this region.

Along with soil stored moisture at the time of planting, growing season precipitation (May 1 - September 30) is among the most important factors influencing crop yields. The rain shadow effect of the Rocky Mountains on the predominantly westerly air flow has a significant influence on the fact that much of the prairie region is usually relatively dry. In most regions of the prairies, total precipitation (rainfall and snowfall) ranges from 300 to 500 mm annually.

Although total precipitation is quite limited, it is fortunate that as illustrated in Figure 6, the seasonal distribution of precipitation can be quite favorable. Peak crop demand for moisture is quite closely aligned with average monthly rainfall patterns. Of the total precipitation, about 60% falls during the growing season (i.e. May and August). This pattern is a major factor contributing to reasonable crop production potential in a region of limited moisture. Unfortunately, individual years frequently experience wide departures from mean precipitation values. Storage of rain and snow water that falls in the non-growing season is usually critical to successful crop production. Therefore clay soils which are more effective in storing water tend to be the most productive soils in the drier regions.

As previously mentioned, year to year variations in amount and distribution of precipitation can be very significant (see Figure 7) and this fact frequently imposes severe hardship on prairie farmers. The highest rainfall amounts tend to be concentrated in the areas associated with the black and gray soil zones that are located in the most eastern, northern and western parts of the prairie agricultural region.

On average, snowfall accounts for 25-30% of the total precipitation. However, snow does not always make an important contribution to the soil moisture reserves due to high potential losses. The amount of snow melt that penetrates into the soil, or runs off into sloughs depends on the amount of snow present, the rate of melting and the state of the soil at the time of thawing. The prospects for soil storage of moisture received as snow is actually much lower in the driest parts of the prairies where its potential contribution to crop production is most critical. In the southwestern part of the prairies, warm, dry mountain winds frequently evaporate a large proportion of the moisture (i.e. sublimation) that falls in the form of snow. This is also the region of highest risk from drought.

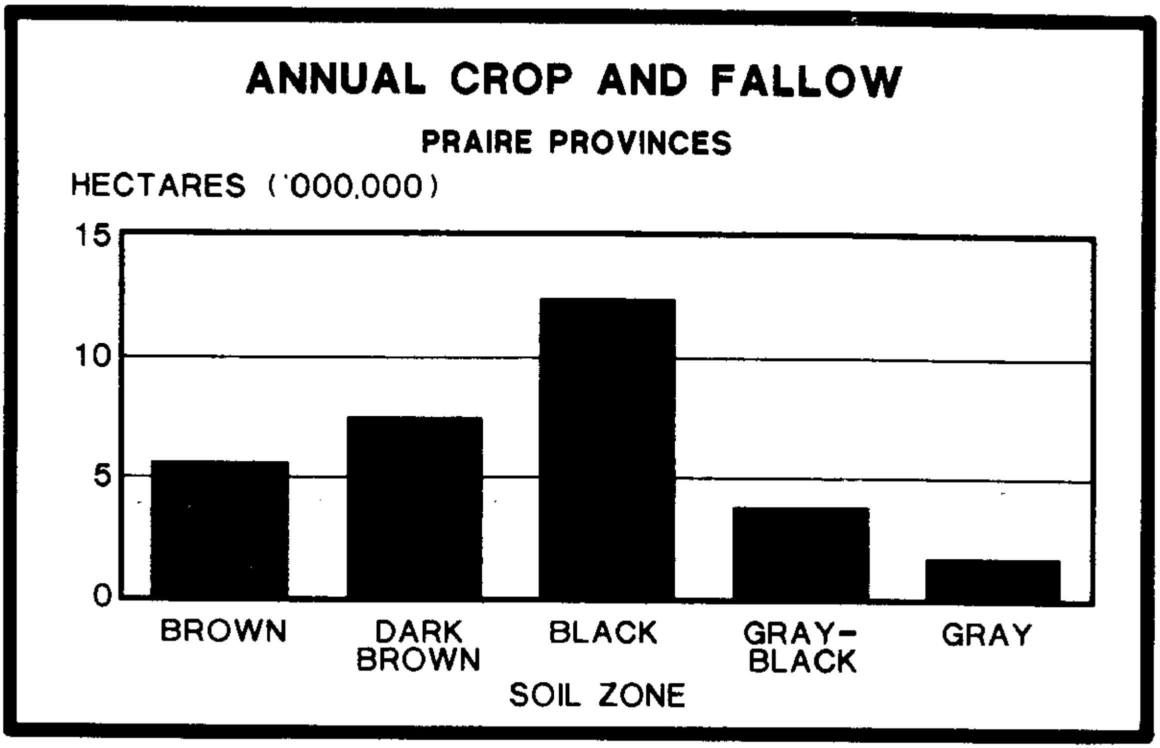


Figure 5. Amount of annually cultivated land contained in the main soil zones of the three prairie provinces.

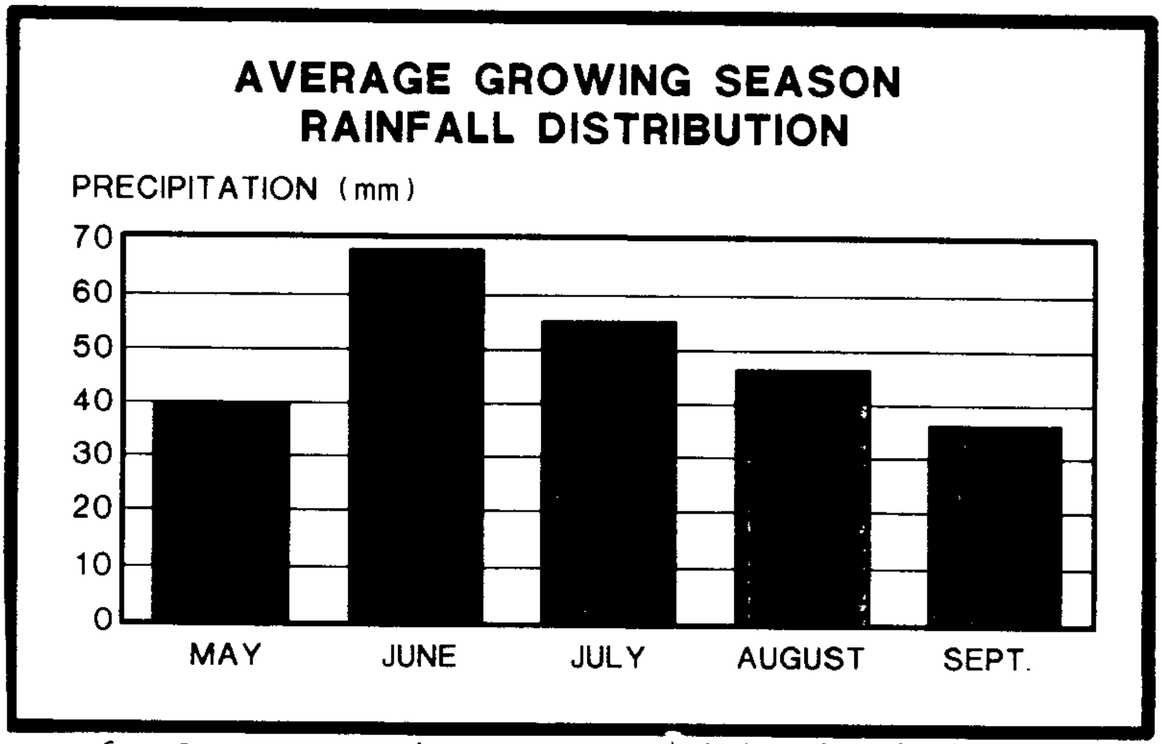


Figure 6. Average growing season precipitation in Saskatchewan based on data collected at thirty stations, 1951-80.

Sublimation of winter moisture is favoured by the presence of recurring warm air circulation from the mountains. The air involved originates over the Pacific Ocean. This air gains heat by the process of condensation as it is forced over the mountains. Having lost moisture, the air mass warms more rapidly (due to compression) as it descends on the east side of the mountains. These "Chinook" winds occur most frequently during the fall, winter and spring of the year and are generally considered beneficial by ranchers since the loss of snow cover enables them to range cattle for much longer periods of time than is possible in the rest of the prairie region. These warm westerly winds provide a particularly welcome break from a spell of cold winter weather. The impact of the "Chinook" winds can be quite dramatic since they can cause a temperature increase of 30°C within a period of several hours. Displacement of these warm winds by cold arctic air can result in equally rapid drops in temperature. However, the occurrence of these hot, dry winds during the summer months can have a devastating effect on yields because of the significantly higher evapo-transpiration demand that is placed on the crops. These winds are frequently an important factor in determining the severity of moisture stress to which crops are subjected in the southwestern portion of the prairies.

EVAPO-TRANSPIRATION POTENTIAL

Although the importance of precipitation to agriculture is self-evident, this parameter alone does not adequately describe the agricultural potential as far as the water requirements of crops are concerned. In addition to precipitation, the high potential evaporation rates provide an indication of rate of water use necessary for crops to sustain adequate growth. Increased air temperature, wind speed and reduced relative humidity increase the amount of water used by crops. Potential evapo-transpiration during the May-July period can range from 300 mm in the higher rainfall regions associated with the black soil zone up to 500 mm in the lower rainfall regions associated with the brown soil zone. During the growing season, on a monthly basis, evaporation potential is often double or triple the average precipitation rates for some prairie locations (refer to Figure 8). Moving in a southeasterly direction across the main agricultural region of Alberta, it is apparent that the difficulties imposed on annual crop production are severly compounded by increasing evaporation potential (Figure 9). Higher evaporation rates contribute to lower moisture use efficiency by crops and are often a key factor contributing to severe moisture stress in crops.

MOISTURE PROBABILITIES

The probability of receiving sufficient moisture to sustain continuous production of crops decreases significantly on proceeding from the black to the brown soil zone. Therefore the contribution of soil stored moisture that is received outside of

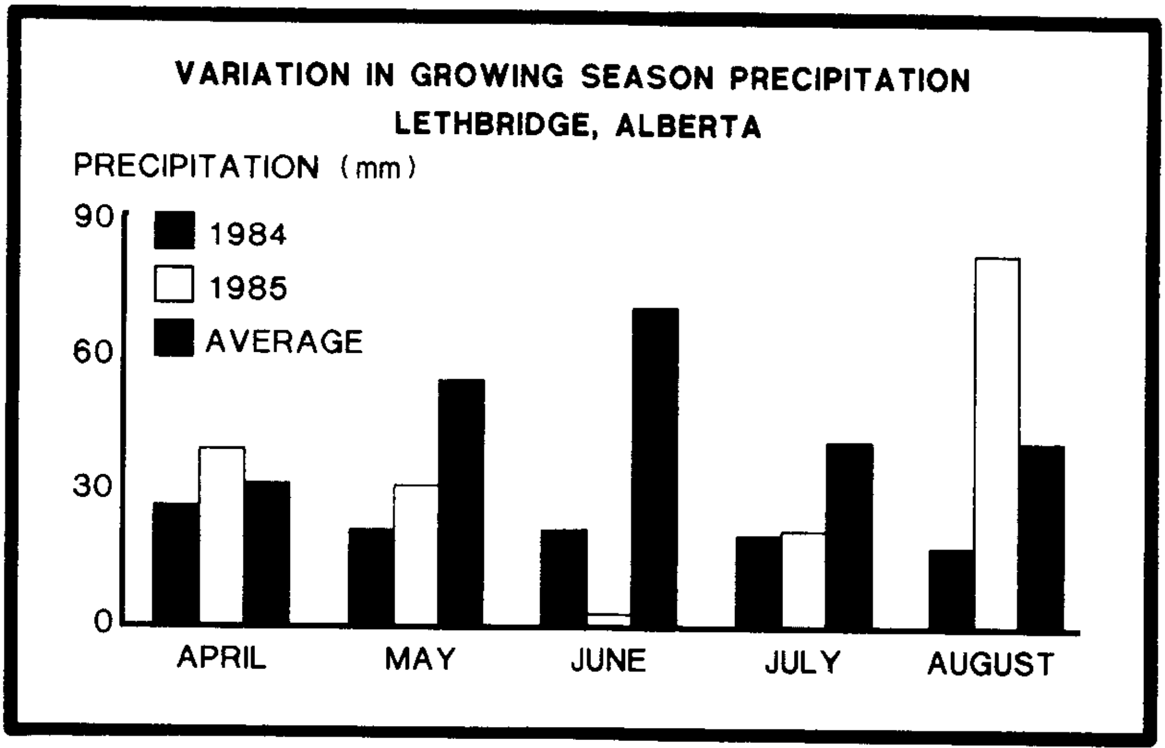


Figure 7. Variations in growing season precipitation recorded at Lethbridge, Alberta in 1984 and 1985 compared to long-term average rainfall data.

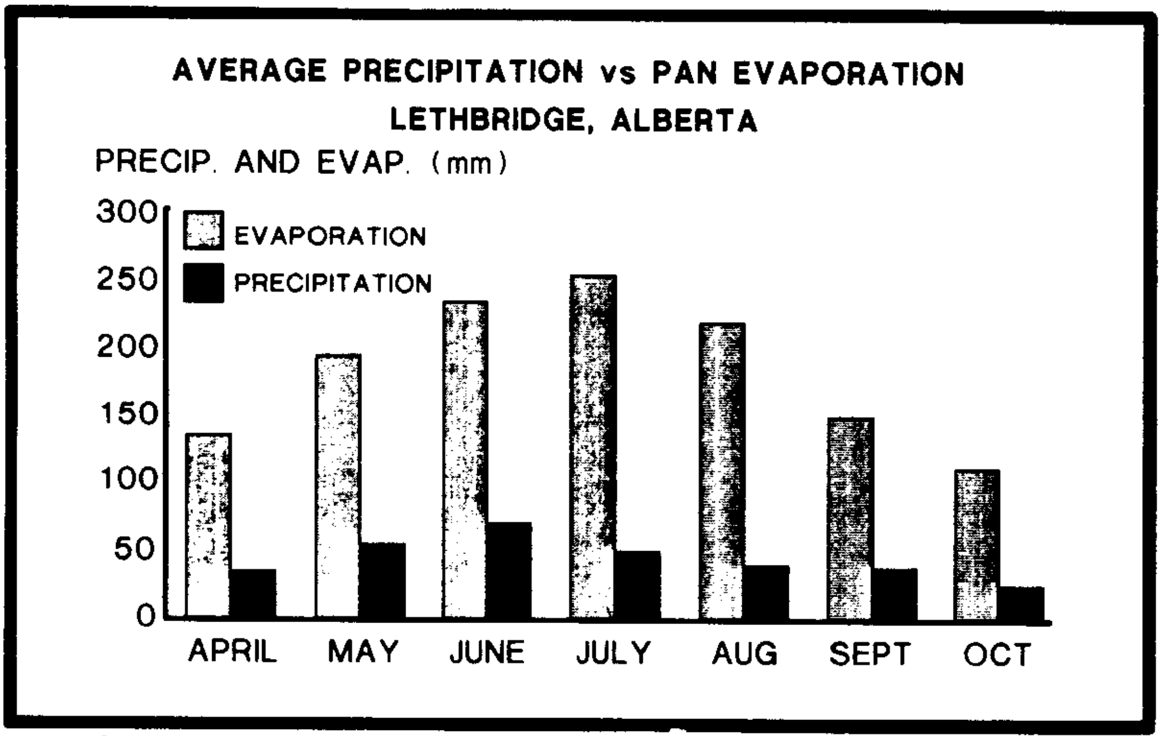


Figure 8. Average pan evaporation compared to average rainfall recorded in the southwestern prairies (Lethbridge, Alberta).

the normal growing season to successful crop production is usually much more critical in the drier regions. However, in the brown soil zone, the amount of soil moisture stored from harvest to seeding can be quite variable (i.e. ranging from 10 to 120 mm). In addition, the probability of obtaining 150 mm of growing season precipitation in the brown soil zone is only about 50%. Since production of a satisfactory crop of wheat requires at least 250 mm of moisture, soil moisture reserves at the time of seeding should amount to 80 to 100 mm. In the brown soil zone, this level of soil stored moisture is only present in about 40% of the years.

It is obvious that in the driest parts of the prairies, attempting continuous crop production is impractical given the severe moisture limitations that are inherent to the region. In these areas farmers have traditionally adopted the practise of leaving the land idle every second year (i.e. summerfallow) in an attempt to reduce the frequency of crop failure by increasing soil stored moisture reserves. However attempting to increase soil moisture storage through summerfallowing tends to be a very inefficient process and this practise does not necessarily guarantee adequate soil stored moisture for the following crop. During the fallowing process, which extends over a period of 20 to 21 months, only a small proportion of the moisture that is received is adequately conserved. The data summarized in Figures 10 and 11 indicates that moisture conservation is particularly low in the last two segments of the fallow period. Generally, 40 to 50 percent of the total soil stored moisture has been accumulated by the first spring of the fallow cycle.

Improved moisture conservation is receiving a great deal of attention from researchers. Conserving an additional 25 mm of soil stored moisture would, on average, result in additional production of 370 kilograms of wheat per hectare. The problem of inefficient moisture storage during the fallowing process is somewhat less critical on the soils with a high clay content because these soils can effectively retain larger quantities of moisture. Summerfallowing for the purpose of increasing soil stored moisture is a regular practise in the brown and dark brown soils where up to 50% of the cultivated land is fallowed. In contrast, in the higher moisture areas typical of the black soil zone, in some cases only 10% or less of the land is regularly summerfallowed.

PRAIRIE DROUGHT

The climate of the prairies is predominantly continental. A continental climate is typified by wider extremes and greater variability than is a Maritime type of climate. On much of the prairies, agriculture is maintained under very close to minimum climatic conditions. While average conditions may appear to be favourable, extreme deviations are normal. Since precipitation varies a great deal with time, it is reasonable to expect periodic droughts. Therefore production of crops involves a significant

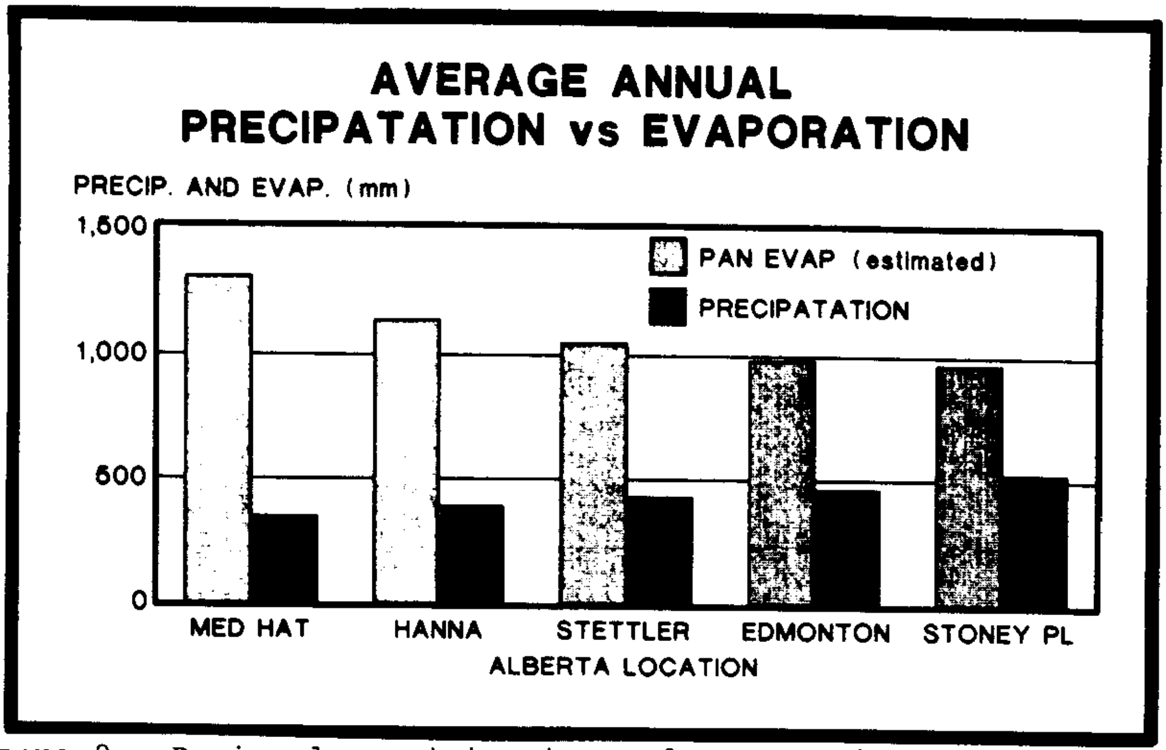


Figure 9. Regional precipitation and evaporation patterns in the agricultural area of Alberta progressing in a northwesterly direction from the southeast.

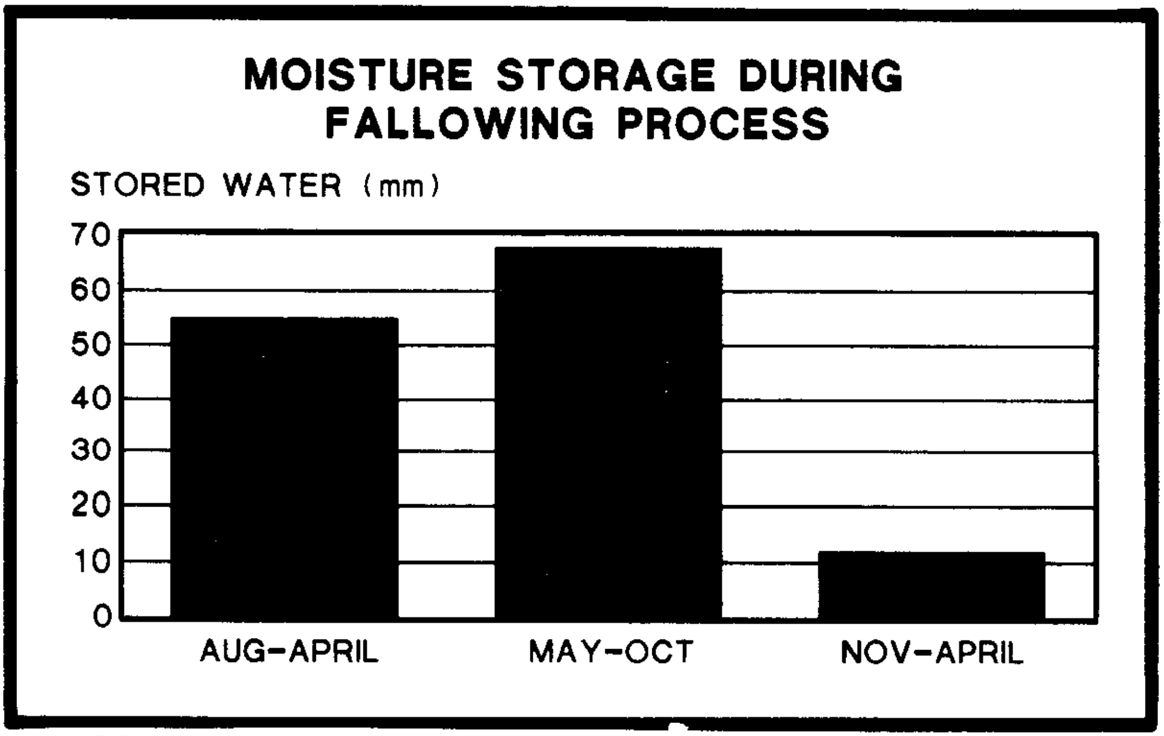


Figure 10. Average amount of gain in soil stored moisture during three successive phases of the summerfallow cycle in the brown soil zone of the prairies.

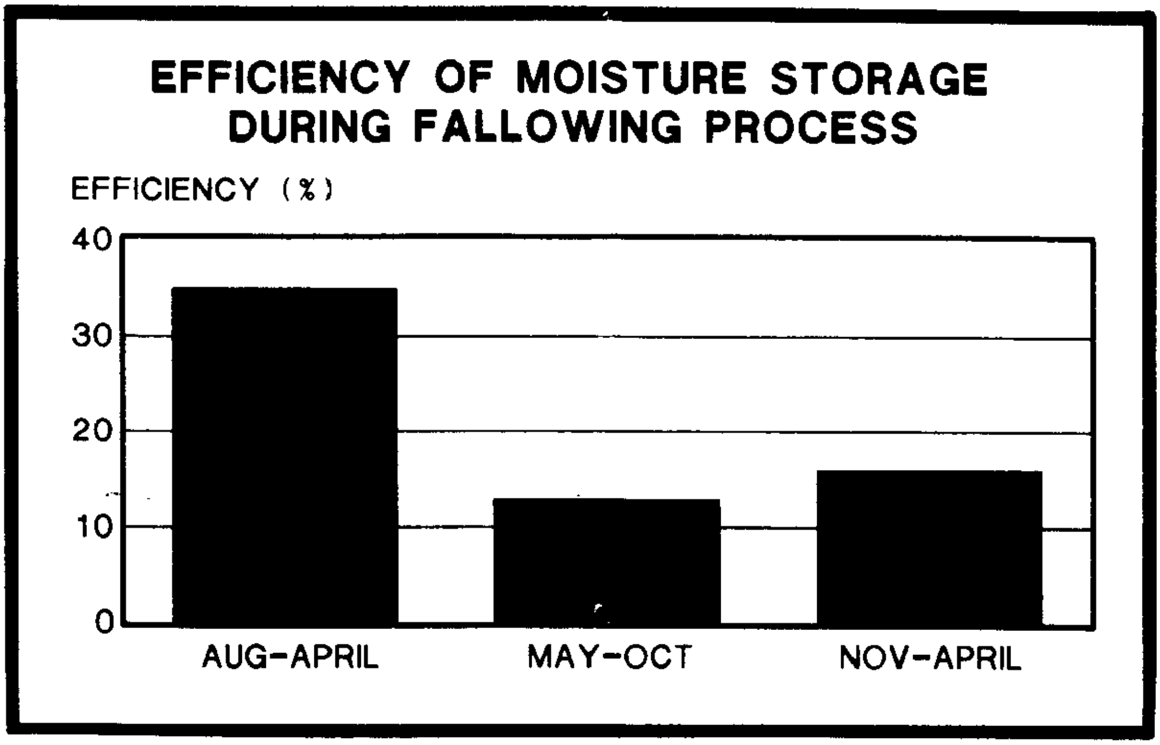


Figure 11. Efficiency of soil retention of precipitation received during three successive phases of summerfallow cycle in the brown soil zone.

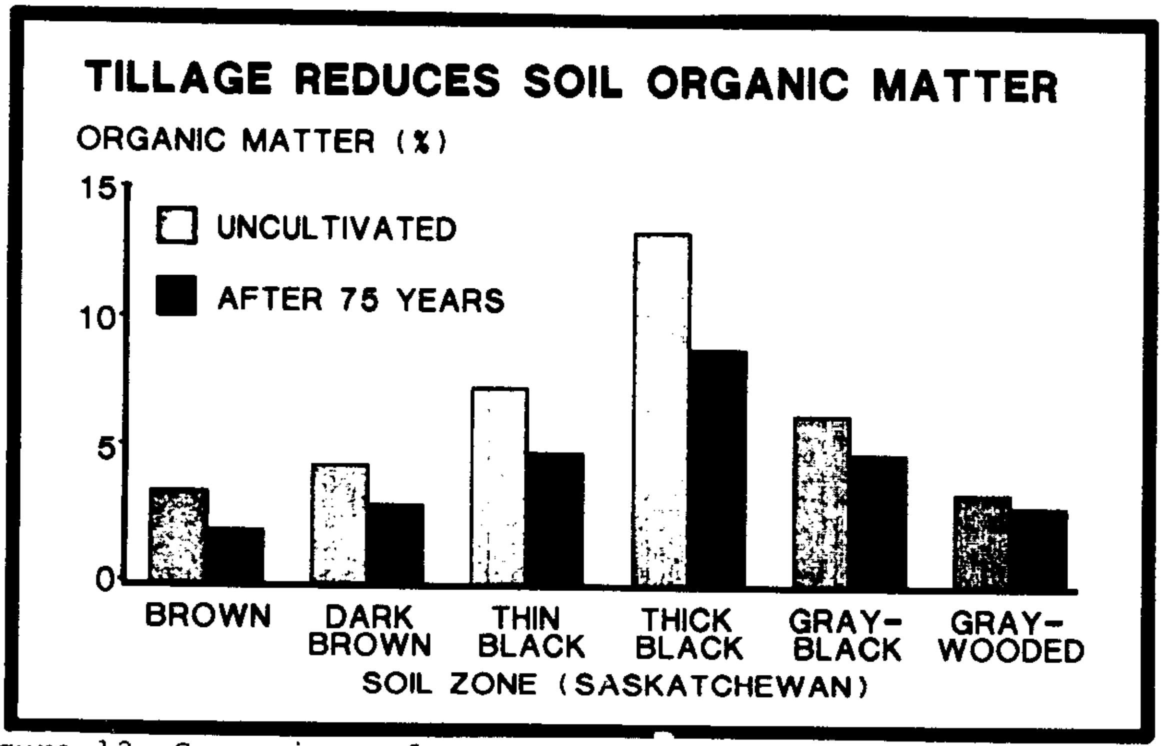


Figure 12. Comparison of average organic matter content of the surface layer of cultivated and virgin soils in six soil zones located in Saskatchewan.

degree of risk. Of the normal climate related risks that prairie farmers have to deal with including spring and fall frost, hail, high winds and drought, the latter has the greatest impact on crop losses. The risk of drought is greatest in the grassland land region associated with the brown soils and is significantly less in the parkland and forested regions associated with the black and gray soils. Drought is generally defined as a period of dry weather of sufficient length and severity to cause at least a partial crop failure. In addition to crop damage, drought can impose significant damage on the livestock industry and increase the risk of soil wind erosion losses.

Droughts can be either regional or local. Much of the summer rainfall results from localized thunderstorms which can repeatedly miss a certain area. It is not only the lack of rain that causes a drought since the timing of precipitation can be equally critical. Therefore two years with almost equal precipitation can result in much different average yields (refer to Figure 7). Regional droughts occur when shifts in large-scale atmospheric systems maintain a dry circulation over the prairie region for extended periods of time.

John Palliser and Henry Hind travelled independently across the Canadian prairie region in 1857 to study the potential of this region for settlement. Their evaluations occurred during a period of drought. Therefore it is not surprising that their pessimistic assessments indicated that much of the area that is now mapped as brown and dark brown soils was deemed to be generally unsuitable for agricultural development. Although these assessments were somewhat hasty and based on a brief period of observation, they did accurately identify the extreme difficulty of attempting crop production on these soils during periods of drought. Adoption of new farming techniques involving soil and moisture conservation have made it possible to produce crops under otherwise severe climatic restrictions. There are however many thousands of acres of land in this region that should probably have never have been broken for grain farming.

Varying degrees of drought have apparently occurred on the Canadian prairies on a recurrent frequency of approximately 20-22 years over the last 150 years. This pattern appears to be directly linked with a similar cycle in sunspot activity. This pattern roughly corresponds to the periods of drought that significantly impacted on the prairie regions during the 1930's, 1960's and 1980's.

DECLINING N-SUPPLYING POWER OF PRAIRIE SOILS

In the brown soil zone, much of the cultivated land is cropped on a two year sequence. That is, a fallow-crop rotation. In the dark brown soil zone, a three rotation is quite common (i.e. fallow-crop-crop). The length of the rotation in the other soil zones tends to be much longer ranging from four in Saskatchewan to ten or more in parts of Manitoba and Alberta.

Prior to the advent of fertilizer and herbicides, the use of fallowing was encouraged to help ensure a crop. Unfortunately, summerfallowing has now been identified as the main culprit responsible for the rather rapid decline in the soil organic matter levels of prairie soils (Figure 12). On most soils, 35-50% of the original organic matter has been lost. The decline in soil organic matter levels has been most dramatic in the brown and dark brown soil zones. The destruction of organic matter has contributed to varying degrees of loss of the favourable soil physical properties that are critical to effective seedbed preparation. In addition, as illustrated in Figure 13, there has been a recent trend indicating a decline in the ability of frequently fallowed soils to release N during the summerfallow period. On an annual basis soil N levels are strongly enfluenced by climatic conditions. Therefore, the actual long-term rate of decline in N-supplying power may not be as consistent nor as rapid as suggested by this graph.

The high levels of N that were typically contained in prairie soils that had been summerfallowed undoubtedly helped contribute to the production of the high protein content of wheat for which the Canadian prairies are recognized. Traditionally, the wheat grown on fallowed land has not received any N fertilizer. It is apparent that if the high protein content of wheat is to be maintained, fertilizer N will have to be applied in these situations with increasing frequency.

Under conditions of longer rotations (i.e. reduced frequency of fallowing) coupled with higher productivity, soil testing has detected a trend indicating increased levels of soil available N (Figure 14). Soils that are subjected to a higher degree of continuous cropping tend to receive higher rates of N fertilizer and this appears to improve the N status of the soil and helps prevent further losses of the soil organic matter reserves.

FERTILIZER N USE PATTERNS

As illustrated by the data presented in Figure 2, during the initial period of fertilizer use, the application of phosphatic fertilizers dominated the prairie market. Of the two options available for application (i.e. drill-in with the seed or broadcast and incorporate), the latter proved to be significantly less effective. Therefore the vast majority of the fertilizer used was applied at the time of seeding. As the use of N fertilizers was gradually introduced, seedrow application was also the preferred method of application for nitrogen as long as rates of application remained relatively modest. As illustrated in Figure 15, the N market was dominated by ammonium nitrate for many years. This is the source of nitrogen that is most adaptable to seedrow application.

As rates of N application increased, farmers switched to applying the nitrogen in a separate broadcast application in order to prevent germination damage and to avoid seeding delays. Therefore, for many years, fertilizer application typically

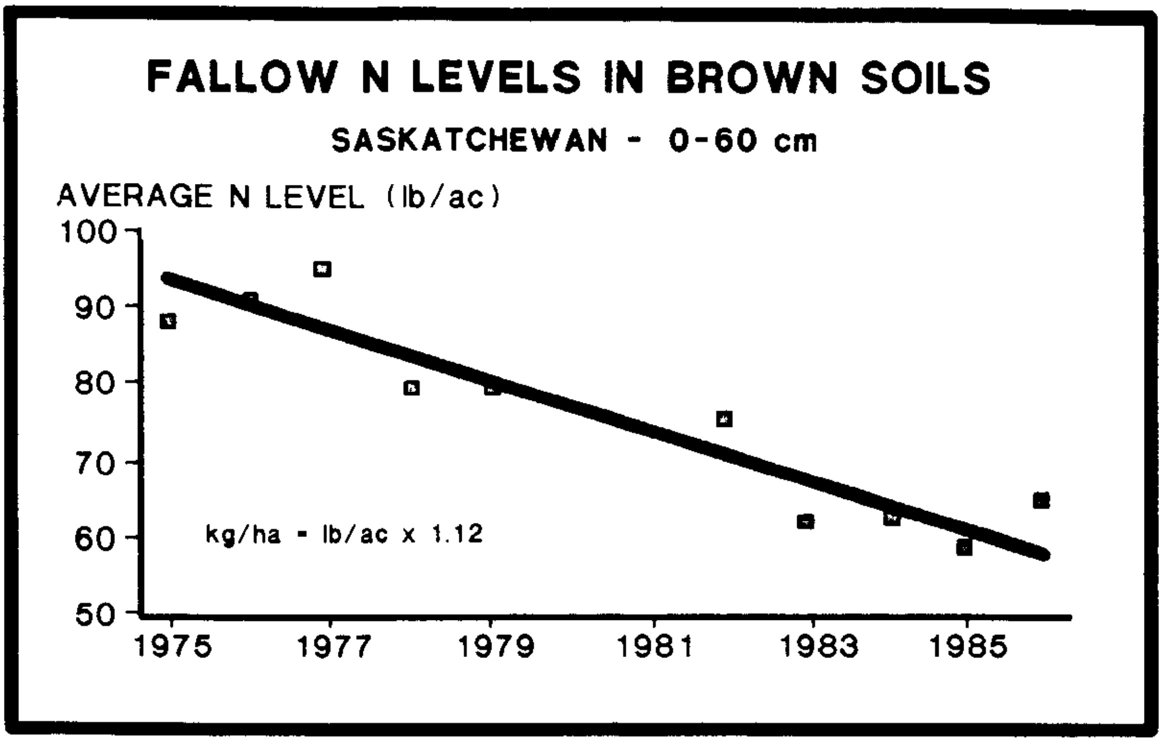


Figure 13. Recent decline in the average N-supplying power of summerfallowed fields located in the brown soil zone of Saskatchewan.

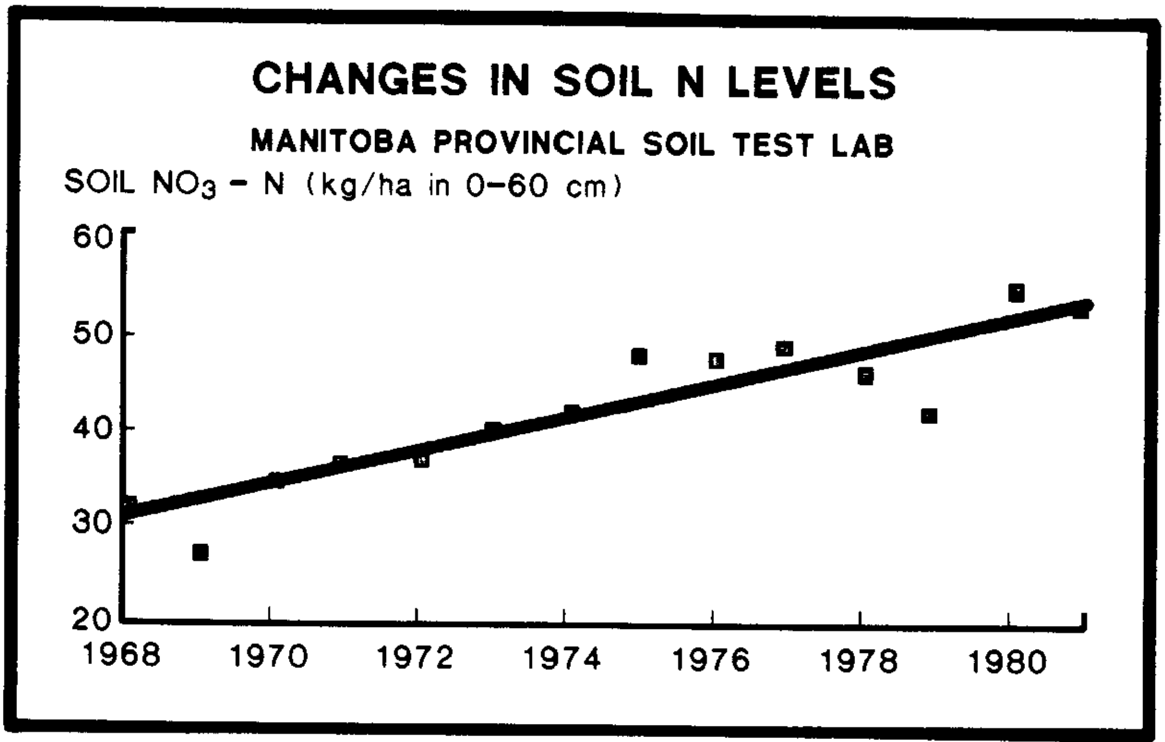


Figure 14. Gradual increase in the soil N-status of frequently recropped and fertilized fields located in the black soil zone of Manitoba.

consisted of broadcast and incorporated nitrogen applied prior to seeding and drill-in phosphate applied at the time of seeding. This approach to N application often resulted in poor responses to the N fertilizer, particularly in dry years. This fact caused some researchers to examine other fertilizer placement options that might be better suited to the relatively dry climate that is typical of the prairie region.

Important changes were also taking place in the forms of nitrogen that were available to prairie farmers (refer to Figure 15). The high market share that was initially enjoyed by ammonium nitrate was being seriously eroded, first by anhydrous ammonia and secondly by urea. In the case of anhydrous ammonia, the nature of the product dictated that it had to be injected (i.e. banded) into the soil. Research proved that favourable farmer comments about the relative performance of anhydrous compared to broadcast applied granular fertilizers resulted from the superior placement that occurred in the case of anhydrous ammonia. This fact forced the development of equipment to band apply granular N fertilizers. Granular banding equipment proved to be particularly advantageous for urea since this N fertilizer was more vulnerable to volatilization losses than other granular fertilizers particularly if it was not properly incorporated into the soil.

BANDING ADVANTAGE

The advantage for banding over broadcasting granular urea is illustrated in Figure 16. This data was collected from a large number of trials conducted in the black soil zone of the eastern prairies. In these trials the broadcast nitrogen was incorporated more thoroughly than would be the case in most farms. Therefore in a farm situation, the advantage for banding would be greater than the substantial advantage indicated in this research data. Generally, the longer the fertilizer is applied prior to initiation of crop growth, the greater the advantage for banding over broadcasting. This advantage is apparant in Figure 16 in that the banding advantage is larger when the fertilizer is fall applied compared to a spring application.

Research information has also demonstrated that the advantage for banding over broadcasting increases in significance under conditions of reduced growing season rainfall. This will especially occur if the crop has excellent sub-soil moisture reserves on which it can draw to compensate for reduced rainfall. As illustrated in Figure 17, as the weekly amount of artificially applied moisture was reduced, the advantage for the band over the broadcast application was significantly increased. This study was conducted during a year of limited early growing season rainfall. This fact combined with excellent soil moisture reserves at the time of planting, coupled with the adequate rainfall during the grain filling period, resulted in an equally large advantage for banding under natural rainfall conditions. The advantages for banding under field conditions are seldom as large as those observed in this study.

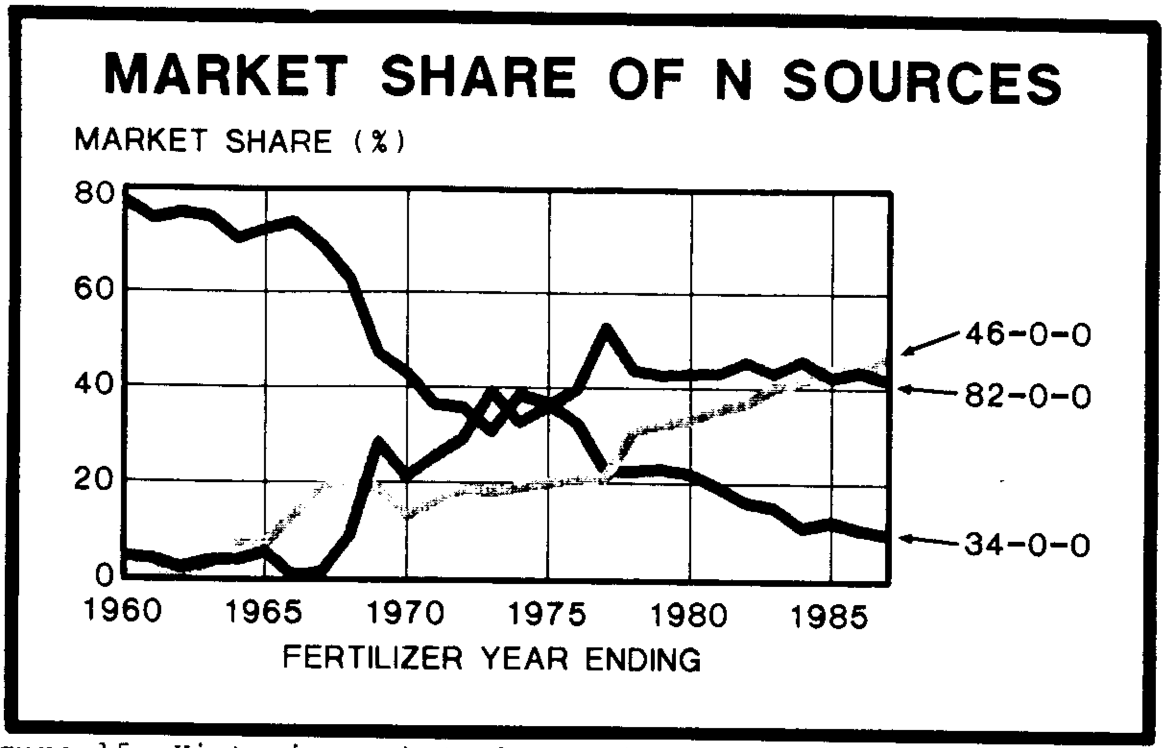


Figure 15. Historic market share of the three main sources of N in the Western Canadian fertilizer market.

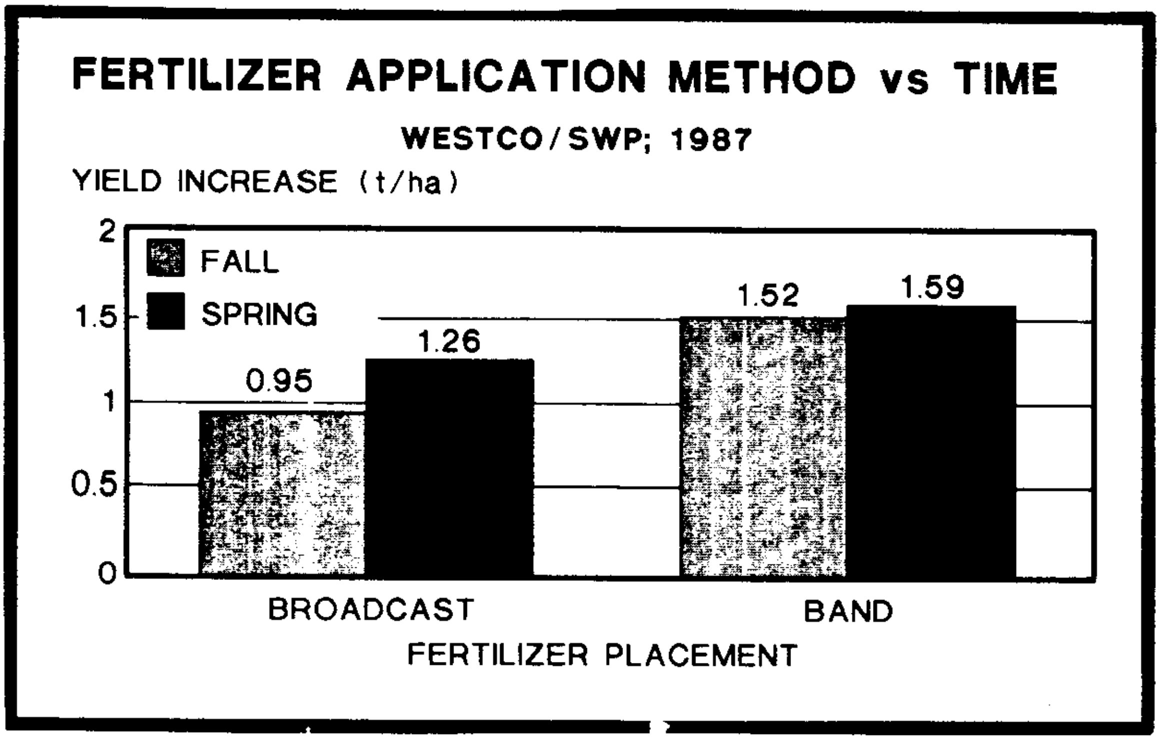


Figure 16. Average response to N fertilizer in east-central Saskatchewan as influenced by time and method of application.

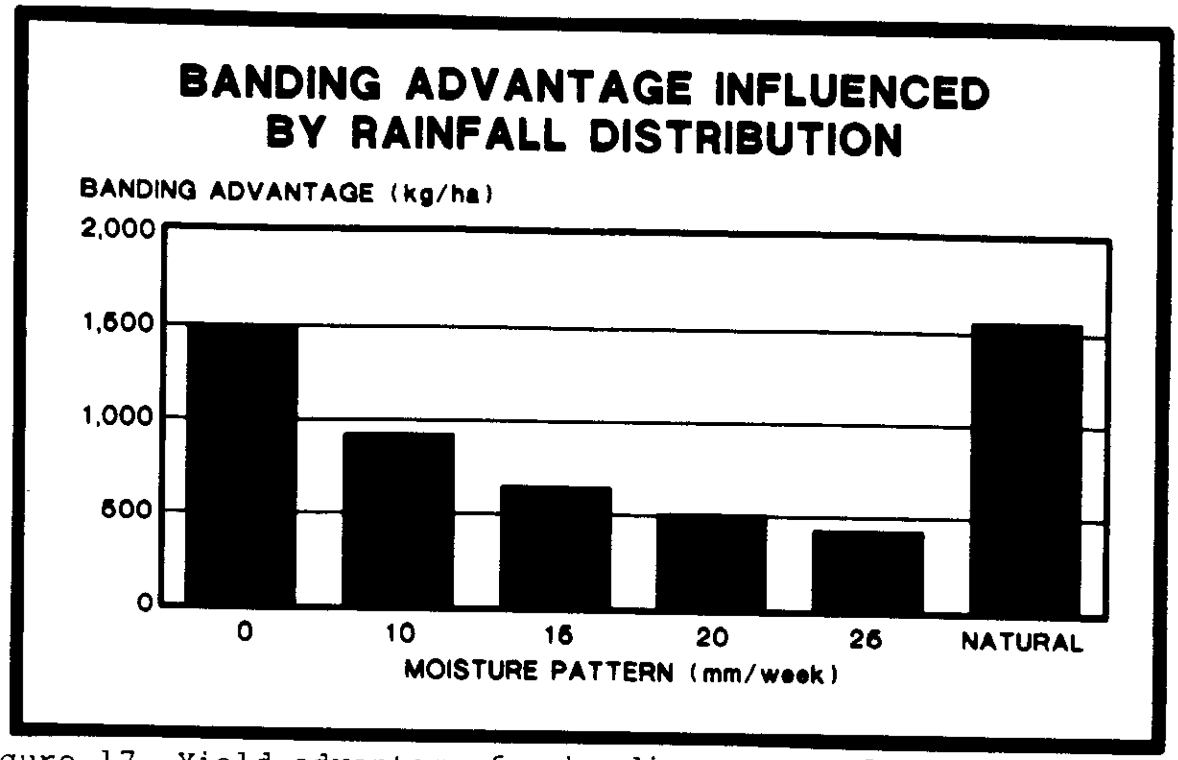
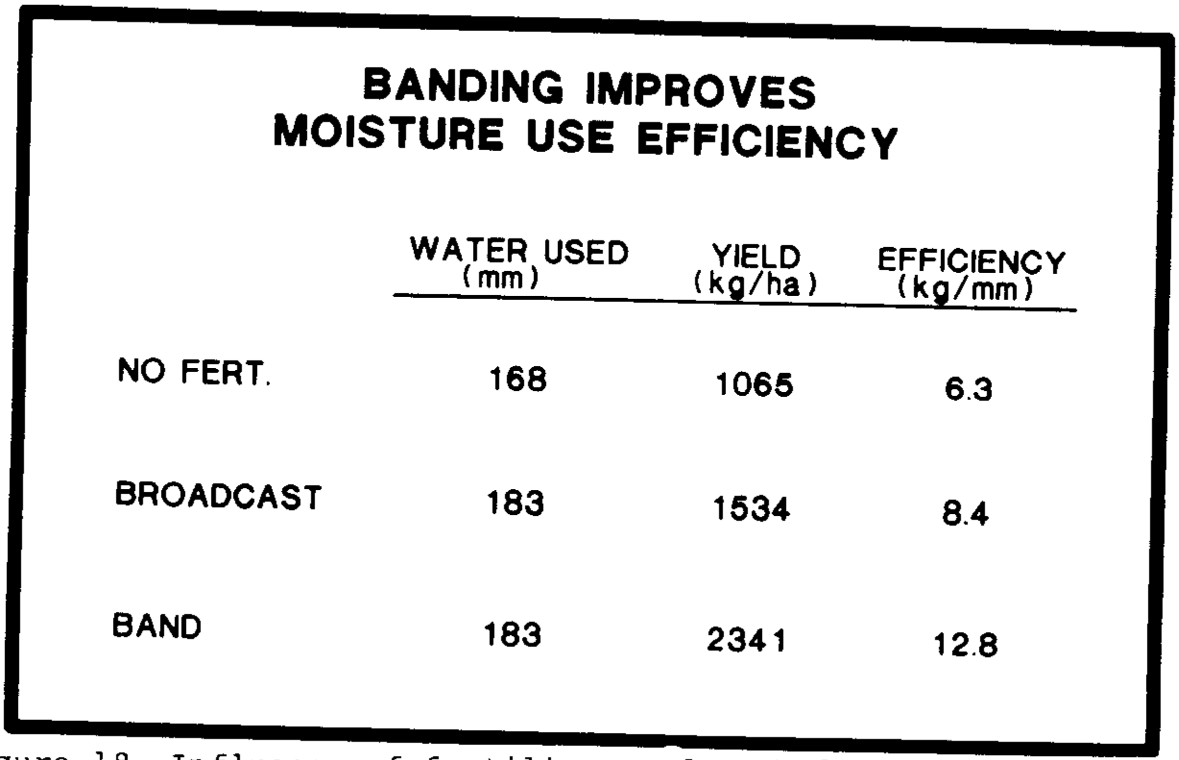


Figure 17. Yield advantage for banding compared to broadcasting as influenced by the moisture regime maintained from planting to the flowering stage of barley.



BANDING IMPROVES MOISTURE USE EFFICIENCY

	WATER USED (mm)	YIELD (kg/ha)	EFFICIENCY (kg/mm)
NO FERT.	168	1065	6.3
BROADCAST	183	1534	8.4
BAND	183	2341	12.8

Figure 18. Influence of fertilizer and method of application on moisture use efficiency of barley grown in southern Alberta.

BANDING VS MOISTURE USE

The information presented in Figure 18 clearly illustrates that band placement of fertilizer can increase the efficiency with which the crops utilize available moisture. In this study, band application contributed to a 50% increase in moisture use efficiency. Improved crop moisture utilization is of vital importance in the prairie region where moisture supplies are usually less than ideal. It should, however, be pointed out that fertilizer placement is not a substitute for moisture. Under conditions of severe moisture stress, improved fertilizer placement is of little practical value.

IMPACT OF REDUCED TILLAGE

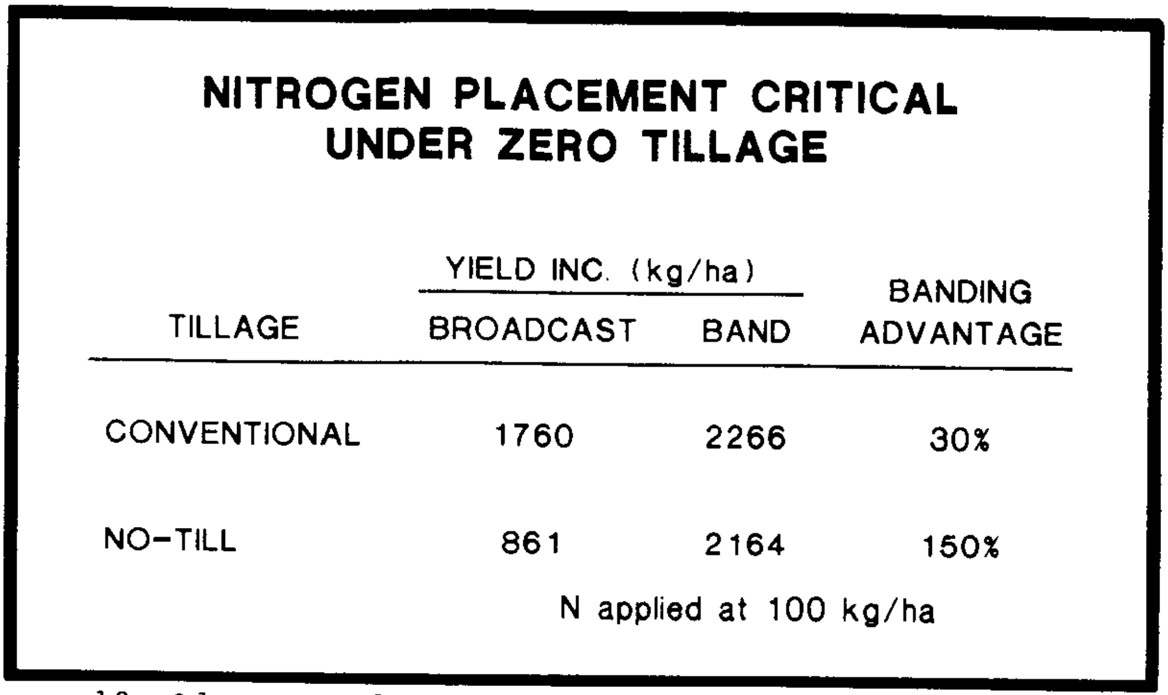
Increased energy costs have forced prairie farmers to re-examine their tillage practices. Surveys confirm that these farmers have significantly reduced the average number of tillage operations they conduct during the past decade. Since extra tillage can increase the performance of broadcast applied fertilizer, this development has important practical implications for fertilizer placement in the prairie region. As illustrated in the data presented in Figure 19, the advantage for banding rather than broadcasting of the required N was much greater for wheat planted under no-till conditions (i.e. direct seeding into untilled soil) compared to a wheat crop planted on conventionally tilled land. As the frequency of tillage is reduced, the need for improved fertilizer placement becomes more critical.

COMBINED N-P BANDING

In the interest of speeding the seeding operation, farmers who have had good success with pre-plant band applications of N became interested in banding all of their fertilizer requirements prior to seeding. As illustrated in the information presented in Figure 20, the response to seed placed P can exceed the response to P that is banded in combination with N in the black soil zone while the opposite was true in the brown soil zone. The benefit of placing at least some of the P in the seedrow is greatest under conditions of favourable soil moisture, cool spring soil temperatures and low soil P levels. The need for splitting the required P betrween the seedrow and the dual N-P band appears to be more important for canola (i.e. rapeseed) than for cereal crops.

N INTERFERENCE WITH P UPTAKE

At higher rates of N application (e.g. exceeding 90 kg/ha applied in bands spaced 30 cm apart), it appears that N fertilizer can initially interfere with P uptake from dual N-P bands. As illustrated in Figure 21, lower rates of N application enhanced crop recovery of radioactively labelled P fertilizer. However, at higher rates of N application P uptake was significantly depressed. This interference is temporary and can be overcome by allowing the dual N-P bands to incubate in the soil for a period of 3 weeks prior to planting of the crop. Unless the N-P bands are fall applied, a 3 week delay in the spring of the year may not

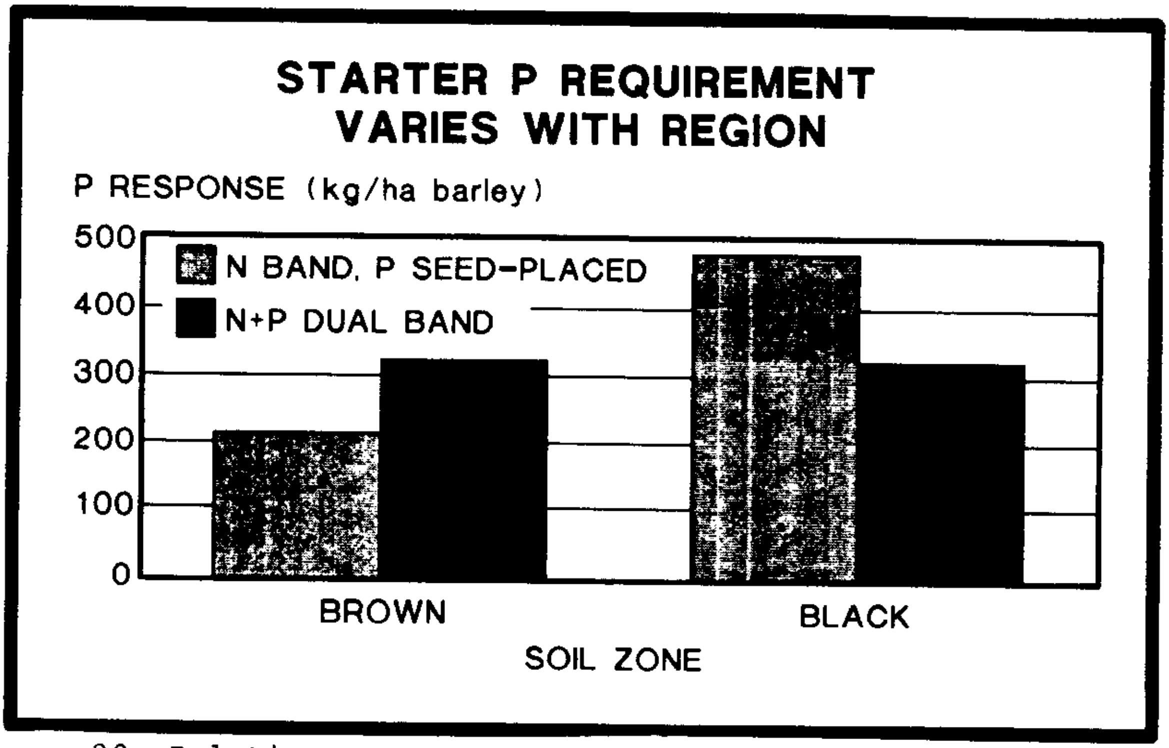


NITROGEN PLACEMENT CRITICAL UNDER ZERO TILLAGE

TILLAGE	YIELD INC. (kg/ha) BROADCAST	YIELD INC. (kg/ha) BAND	BANDING ADVANTAGE
CONVENTIONAL	1760	2266	30%
NO-TILL	861	2164	150%

N applied at 100 kg/ha

Figure 19. Advantage for banding compared to broadcasting N for wheat grown under conventional and no-till conditions.



STARTER P REQUIREMENT VARIES WITH REGION

Figure 20. Relative response to pre-plant banded phosphate and seed-placed (i.e. starter) phosphate in the brown and black soil zones.

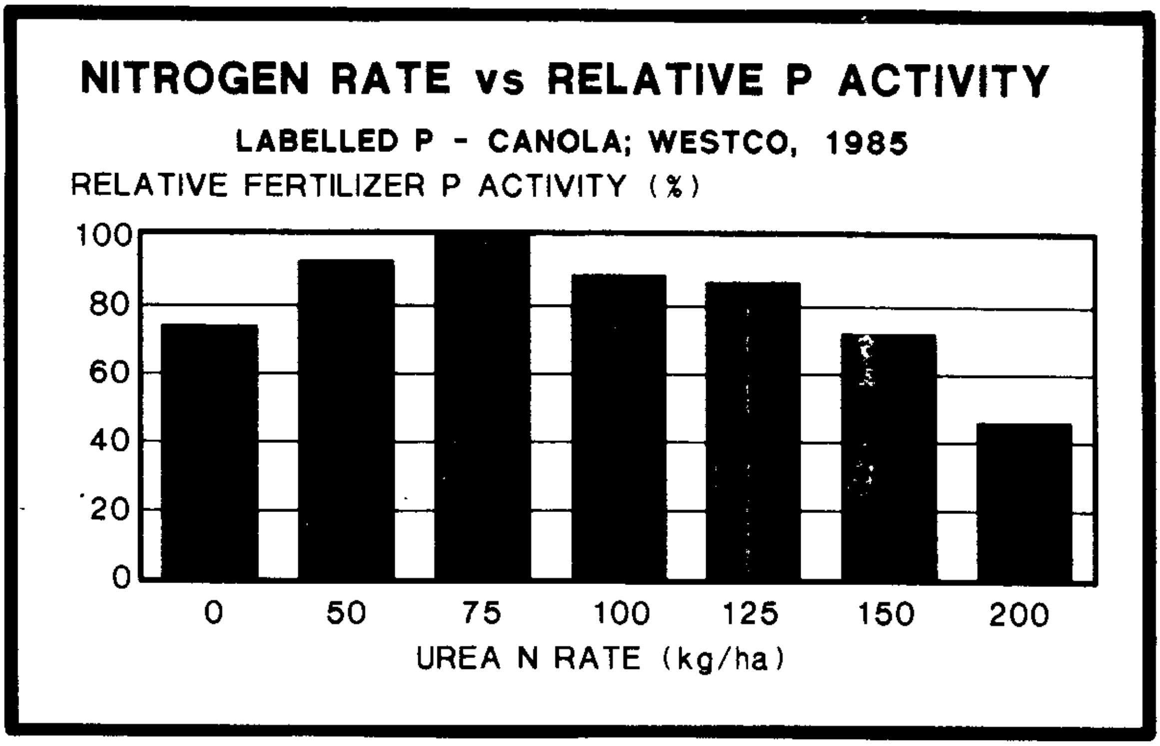


Figure 21. Influence of rate of N applied in dual N-P bands on relative crop uptake of radioactively labelled phosphate fertilizer.

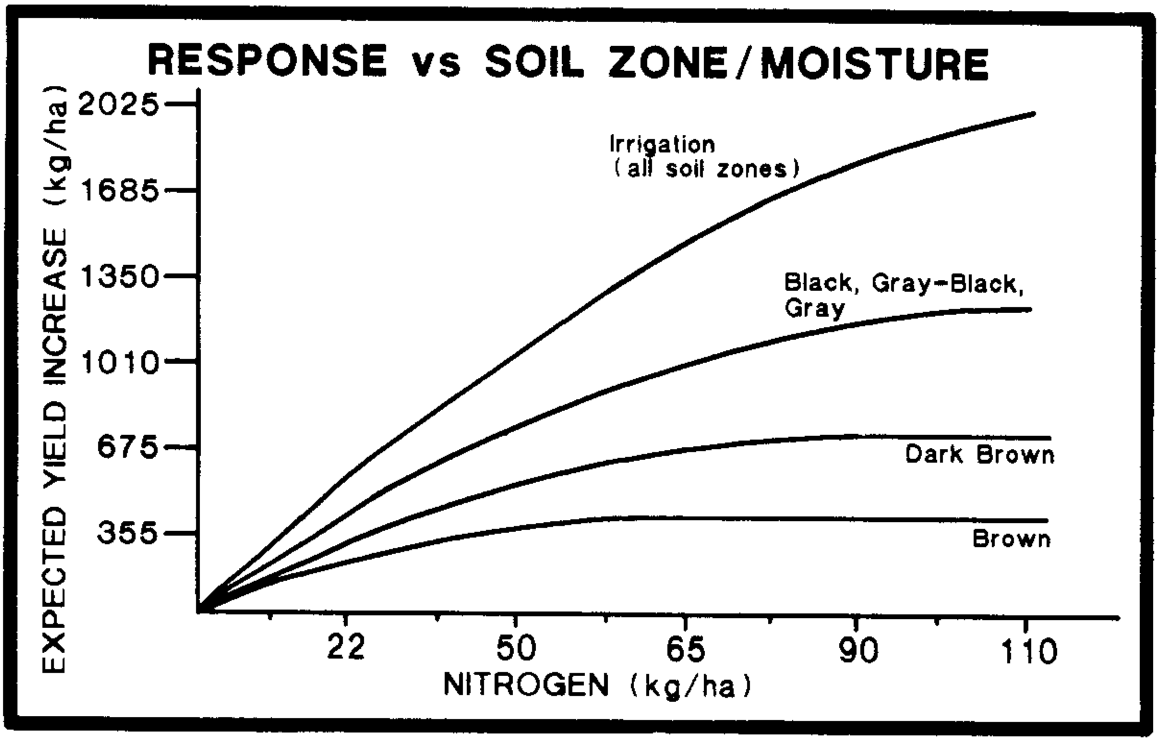


Figure 22. Expected yield response of wheat to N rates on soils containing 18-23 kg/ha of N for average moisture conditions for the various Saskatchewan soil zones.

be practical. Since N concentration in a band is a function of band spacing as well as the rate of application, reducing the band spacing can significantly reduce the risk of N interference with P uptake.

SUMMARY

As illustrated in Figure 22, the average response to fertilizer varies a great deal between the various soil zones. Furthermore, departures from average moisture conditions can contribute to very large fluctuations in production and the response to applied fertilizer. In the drier regions it would not be unusual to obtain a response that was double that indicated in Figure 22. However, in the brown and dark brown soil zones, it would also not be unusual to receive negligible response to fertilizer under conditions of severe moisture stress. The response that is indicated for crops grown under irrigated conditions provides a clear demonstration that moisture is a major limiting factor for achieving higher crop yields. In the province of Alberta, only 4% of the cropped land is irrigated. However, irrigated land accounts for 20% of the agricultural production for the province. These facts help to illustrate the severe constraints that the climate places on the use of fertilizer in the drier regions of the Canadian prairies.

Under dryland conditions, maximum conservation and utilization of the limited amount of precipitation is essential for improved crop production. Capturing an additional 25 to 50 mm of soil stored moisture during the September-April period and the effective use of this extra moisture could help reduce the dependence on the detrimental practice of summerfallowing for moisture storage. Adequate amounts of properly placed fertilizer can also have a pronounced effect on improving moisture use efficiency providing sufficient moisture is received to sustain reasonable plant growth.

TA/88/1 Trends in nitrogen use and application in Western Canada by John Harapiak, Western Cooperative Fertilizers Ltd. Canada

DISCUSSION: (Rapporteur Mr. L.J. Carpentier, IFA)

Q - Mr. F. ACHORN (NFDC/TVA, USA).

You showed increased movement of urea and anhydrous ammonia over ammonium nitrate. I wonder: Has nitrogen solution become a factor in this area as it has in other areas ?

A - The question is : Does it relate to liquid fertilizer ? In most figures, I included the nitrogen, ammonium nitrate and urea, that was used in the liquid fertilizer. Liquid fertilizer has had some impact in Western Canada and there is a growing interest in it; however, it is still not a major part of the market. The trend now, very definitely, is to band liquid fertilizer in our market area, and that has helped increase the acceptability of liquid fertilizers. It has improved their performance, and their acceptance in the market.

Q - Mr. CARPENTIER (IFA, France).

1/ In your paper, your mentioned very low nitrogen rates of application as compared to what we have in Europe and other parts of the world. What kind of yield level do you reach with such rates on the most important crops, such as wheat, barley, and rapeseed ?

2/ You mentioned the switch-over from ammonium nitrate to urea and anhydrous ammonia in recent years. I am rather surprised at this trend because of your climatic conditions and short growth period. Is mineralization and nitrification sufficiently quick to allow for an efficient use of these fertilizers ?

3/ You said that one of the reasons for the good effect of urea is band placement to reduce the losses, but would you not reach the same results by applying ammonium nitrate top-dressed, for example, after tillering ?

A - 1/ The average yield for wheat ranges from 20 bushels to 40 bushels per acre or about 1.2 to 2.5 tons per hectare. There are farmers who exceed those yields. This past year in Alberta, yields have been higher under dryland conditions. However, in the Southwest corner of Alberta and Southern Saskatchewan, there were many fields that were planted this year that were not harvested at all, and some fields yielded as little as 5 bushels per acre.

Barley yields range at, say, from 50 to 90 bushels per acre, or 2.5 to 6 tons per hectare. However, in Alberta, just South of Edmonton, in our test plots where we used some growth regulators and fungicides, we have managed to achieve 180 bushels per acre, or 9.7 tons per hectare. So, in the better moisture area parts of Alberta, certainly - and Manitoba as well - there is potential for increasing those yields considerably. Rapeseed yields, another important crop of ours, will be 25 to 40 bushels per acre or 1 to 2 tons per hectare. Again, we have achieved yields of 70 to 80 bushels per acre under irrigation, but, under dryland, 50 bushels probably is a realistic goal.

.../.../...

Climate, the impact of climate, will change yields a great deal from year to year.

2/ The second question was related to ammonium nitrate and whether urea and anhydrous ammonia are effective replacements. In our cereal trials, we have not found any advantage for ammonium nitrate, in spite of cold spells in the spring of the year, over urea, if they are equally applied. In this case, they are band applied. So mineralization does not seem to be a problem. The conversion from ammonium to nitrate occurs rapidly enough, even though our soils are cold, to meet plant requirements.

It appears that ammonium nitrate does have a significant advantage as a forage fertilizer. In fact, in many cases, urea as a forage fertilizer will only be average 70% as effective as ammonium nitrate. So that means that you are sacrificing a lot of urea. Despite that fact, many farmers continue using urea, and I think that part of it has had to do with the dealer system and the manufacturing system switching to urea and anhydrous ammonia. It appears that, despite the advantages that ammonium nitrate has agronomically, it has not been able to retain its market share. Part of this has been raised at market, manufacturing and transportation costs and also the environmental problems associated with producing ammonium nitrate.

3/ The last question was related to top-dressing ammonium nitrate. Again, we have compared top-dressed ammonium nitrate, urea and liquid fertilizers as well and, if conditions are not favourable - and by that I mean dry weather and very warm winds - we can get severe losses of that fertilizer.

However, if immediately after application we get rainfall, top-dressed fertilizer can, at times, work very effectively. Unfortunately, under our conditions, it is very difficult to predict whether we are going to get rainfall or not. Our weather forecasts have a lot to be desired. If that could be improved, then I think that top-dressing might come into vogue, with ammonium nitrate, although it is declining as a source. There are conditions under which, if moisture conditions improve after seeding, we will recommend that farmers top-dress the nitrogen, but there is an inherent risk involved in that kind of a technique.