Fertilizer Management for Seed Production of Perennial Forage Crops in the Canadian Prairies

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Background

- In the three Prairie Provinces, there are about 280,000 ha (166,000 ha in Alberta, 67,000 ha in Saskatchewan, and 47,000 ha in Manitoba in 2005) under perennial forage seed production.
- Majority of the forage seed is produced in more northern parts, and in this area it is an important cash crop.
- Perennial forages are important for crop diversification and rotation.
- Well-managed forages reduce soil erosion, improve soil quality, increase soil organic matter levels and enhance the sustainability of other agricultural cropping systems.
- Forage seed crops, especially legumes, tended to be grown on less fertile soils, which increase the importance of nutrient management on these crops.
- In general, N and P are deficient under most soil and crop conditions.
- K and S are also deficient in soil in certain areas (Gray and Dark Gray for S, and sandy soils for K).
- Deficiencies of other plant nutrients are not very common.
- The amounts of nutrients required for optimum growth and yield vary widely from year to year for a given crop and also vary considerably from one forage crop to another or with soil type.
- Like most annual crops, perennial forages respond well to the application of fertilizers on nutrient deficient soils.
- The purpose of this presentation is to summarize research information on fertilizer management for improving seed production of perennial grasses and legumes in the Prairie Provinces, mainly from Saskatchewan.

Grasses

Effect of N Fertilizer Rate on Seed Yield

- Magnitude of seed yield increase from N fertilizer depends on climatic conditions, soil type and forage species.

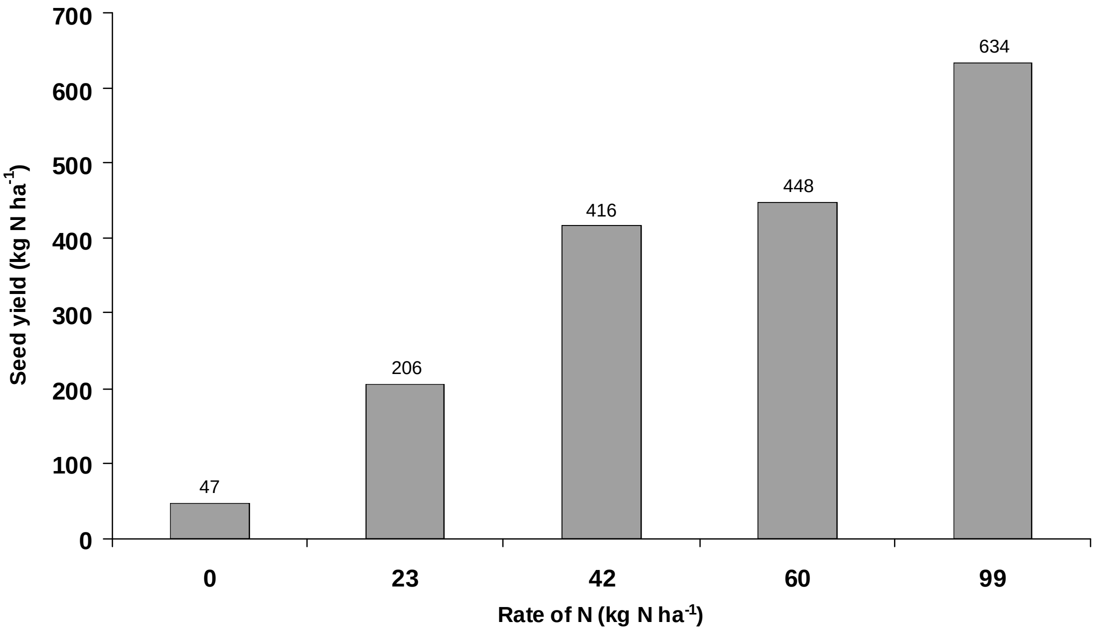

Figure 1. Nitrogen rate effects on seed yield of crested wheatgrass with autumn-applied ammonium nitrate in relatively moist years with average growing season (May to August) precipitation of 285 mm (1954-1957) at Indian head, Saskatchewan (prepared from Buglass, 1964).

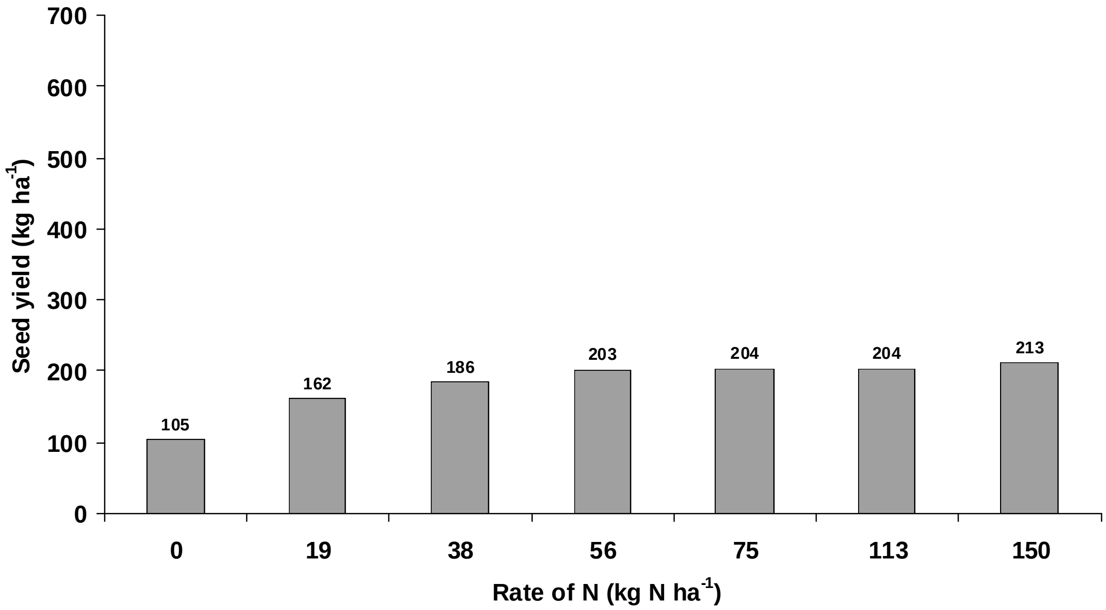

Figure 2. Nitrogen rate effects on seed yield of crested wheatgrass with autumn-applied ammonium nitrate in relatively dry years with average growing season (May to August) precipitation of 150 mm (1959-1962) at Indian Head, Saskatchewan (Buglass, 1964).

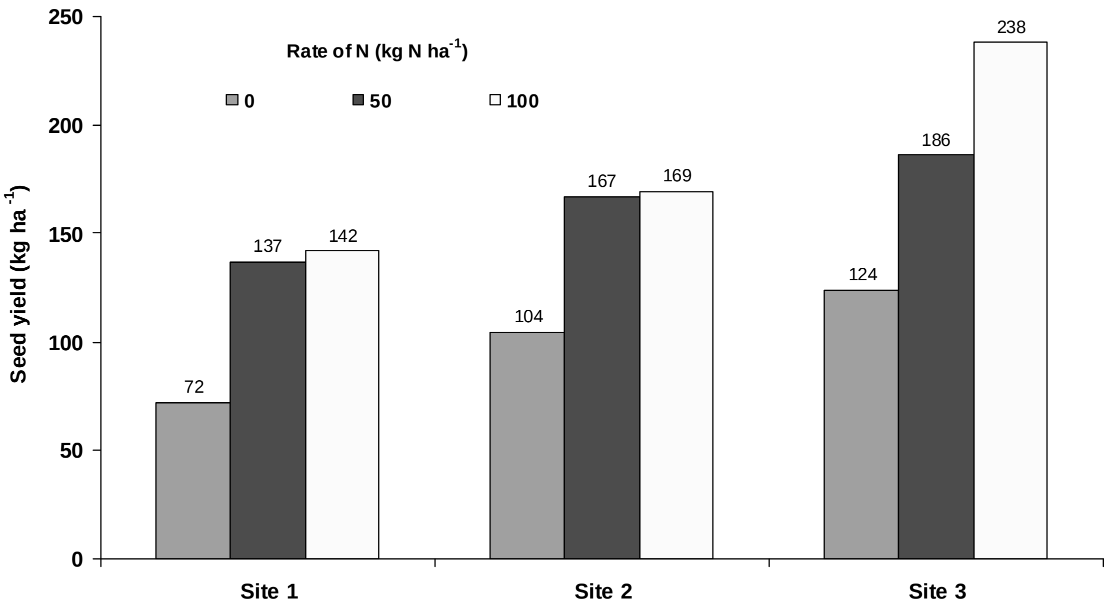

Figure 3. Effect of N fertilization on seed yield of Kentucky bluegrass at three sites near Teulon, Manitoba (Thompson and Clark 1989).

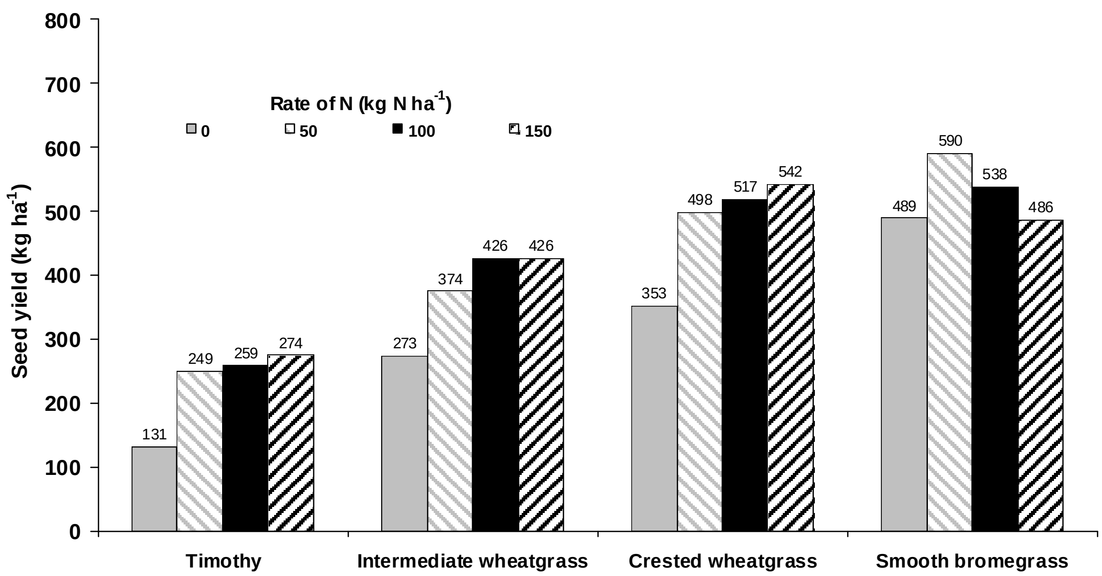

Figure 4. Nitrogen rate effects on seed yield of timothy, intermediate wheatgrass, crested wheatgrass and smooth bromegrass in northeastern Saskatchewan (averaged across P rates from 1989-1991) (prepared from Loeppky et al. 1999).

Effect of Moisture Conditions and N Fertilizer Rate on Seed Yield

Grasses (Loeppky et al. 1999)

- Response of timothy, intermediate wheatgrass, crested wheatgrass and smooth bromegrass to spring-applied N fertilizer was studied in northeastern Saskatchewan from 1988-1991.
- Seed yield of all forage species was significantly increased by N application and generally was dependent on soil and climatic conditions.
- For example, seed yield of smooth bromegrass, the highest yielding species, ranged from a low of 290 kg ha^{-1} in a dry year (1990) to a high of 1240 kg ha^{-1} in a moist year (1989).

Effect of Timing of N Fertilizer Application on Seed Yield

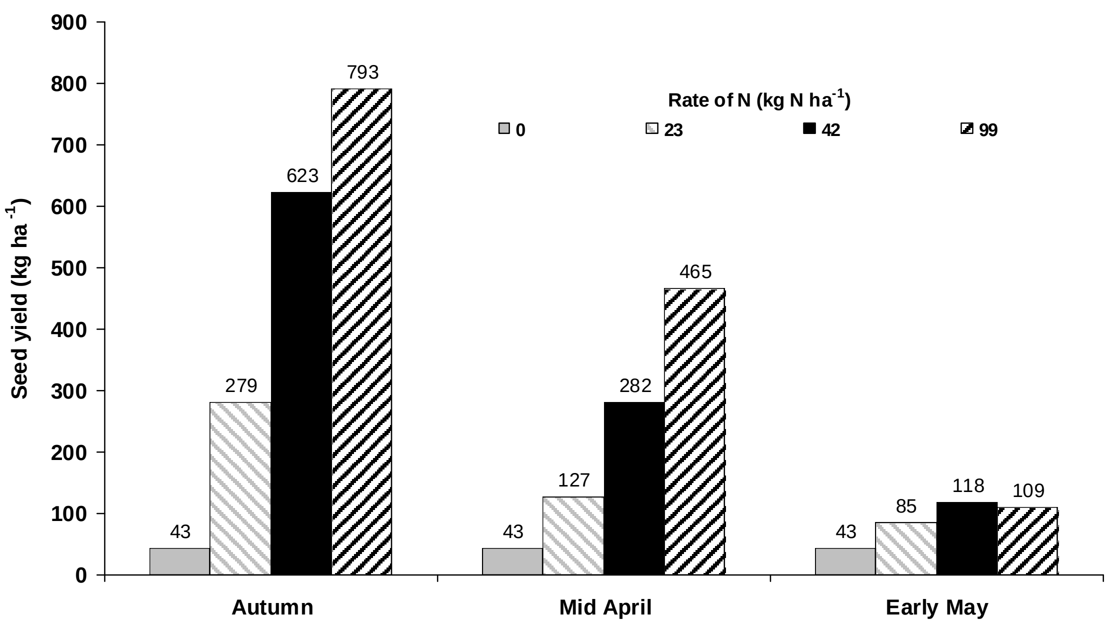

Figure 5. Effect of timing of N application on seed yield of crested wheatgrass in 1957 at Indian Head, Saskatchewan (Buglass, 1964).

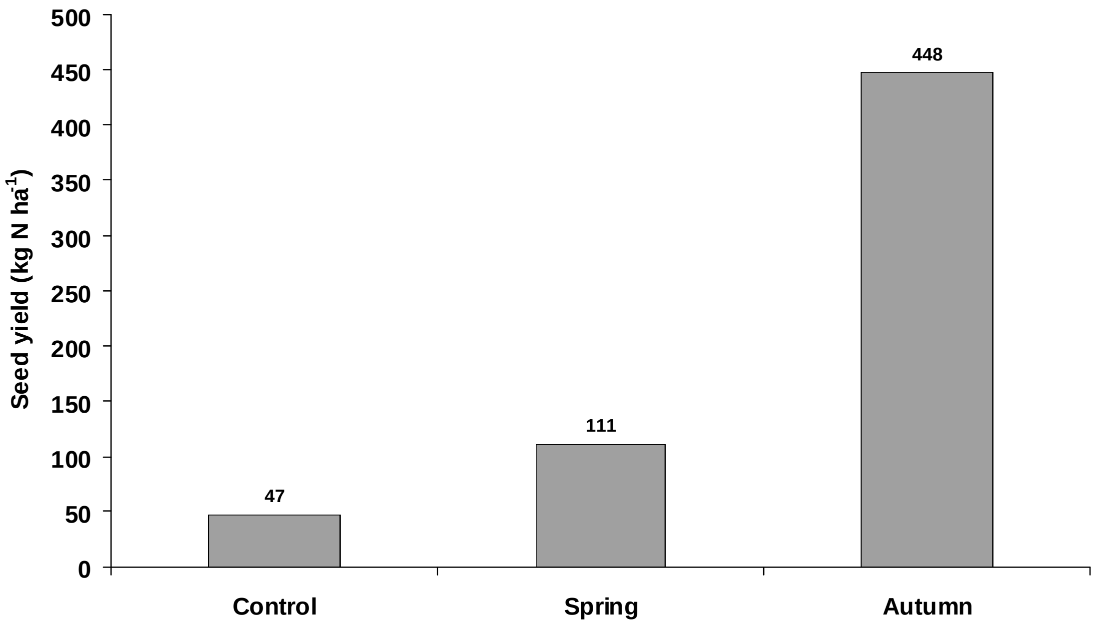

Figure 6. Seed yield of crested wheatgrass with autumn- and spring-applied ammonium nitrate at 60 kg N ha^{-1} in relatively moist years (1954-1957) at Indian head, Saskatchewan (prepared from Buglass, 1964).

Effect of Source of N Fertilizer on Seed Yield

- Form of N can have a major impact on the grass seed yield response, if surface-broadcast is used.

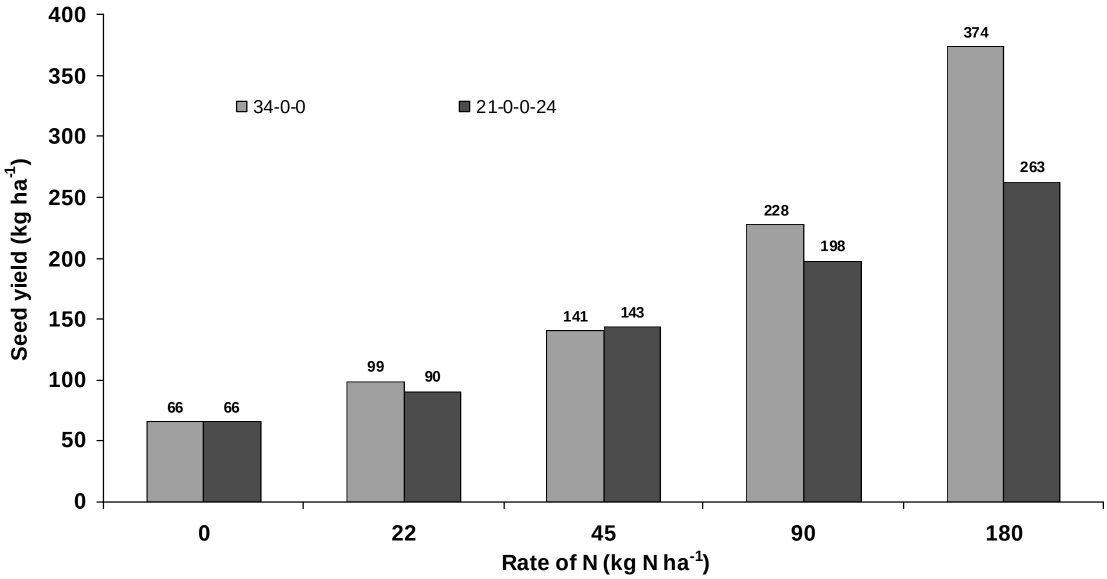

Figure 7. Seed yield response of smooth bromegrass to N source (1950-1951) at Melfort, Saskatchewan (Knowles and Cooke, 1952).

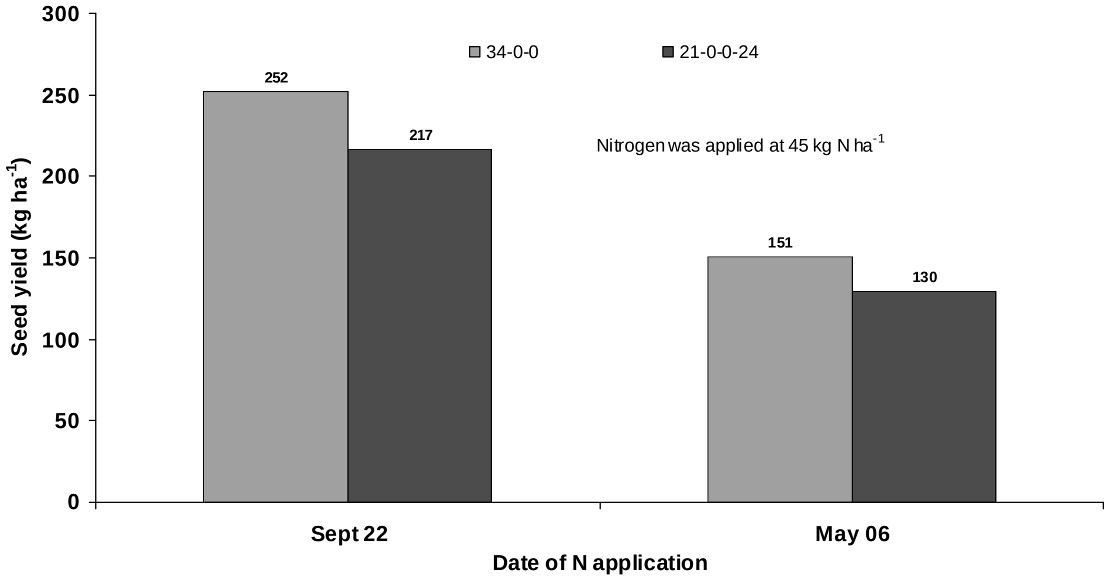

Figure 8. Effect of N form and date of application on seed yield of smooth bromegrass at Unity, Saskatchewan (Knowles and Cooke, 1952).

Effect of N x P Interaction on Seed Yield

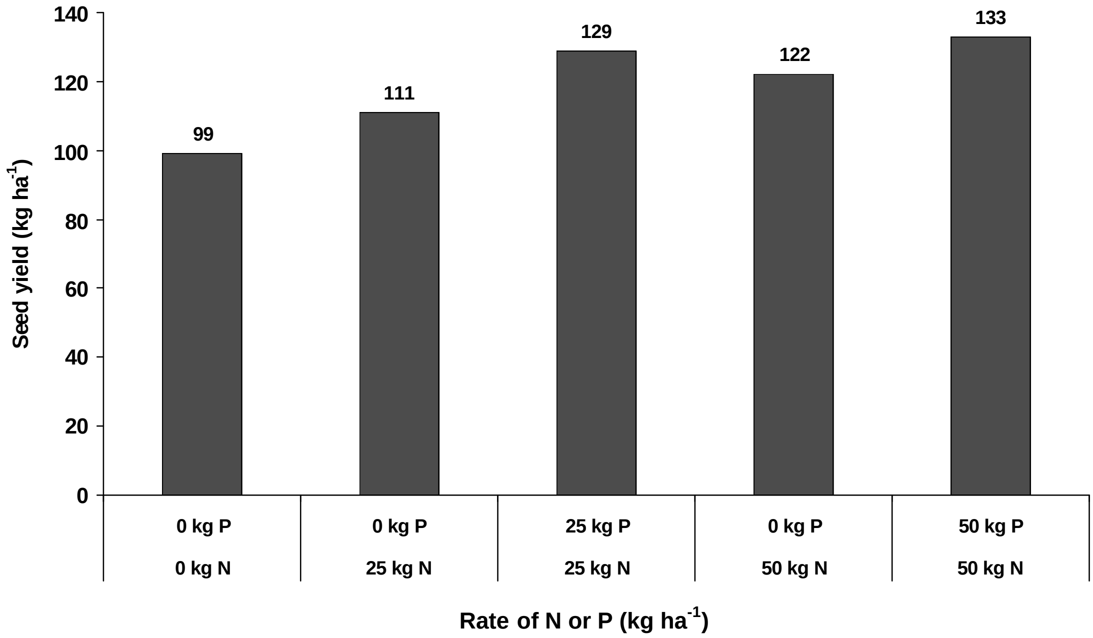

Figure 9. Interaction effect of N and P fertilizers on seed yield of dryland Altai wildrye grass at Swift Current, Saskatchewan (prepared from Lawrence, 1980).

Effect of N Fertilizer Placement and Formulation on Seed Yield

- Fertilizer placement and formulation are also important for optimum seed yield.
- Information is lacking on grass seed stands.

Legumes

- Legumes coexist with *Rhizobium* bacteria that can induce nodulation and convert N_2 from the air to a form that is available to plants.
- Consequently, no N fertilizer is required for legumes provided they are inoculated with appropriate *Rhizobium* bacteria (specific to each plant type) using a proper procedure.
- It is possible the application of N fertilizer may reduce N fixation by the nodulation bacteria.
- The results of field experiments conducted in northeastern Saskatchewan showed that there was no significant increase in seed yield of alfalfa from N fertilization, irrespective of soil type and climatic conditions (Loeppky et al. 1999. CJSS 79:265-271).
- These findings should be applicable to other legume species in general.

Effect of P Fertilizer on Seed Yield

Grasses

- Field experiments to determine the response of smooth bromegrass, crested wheat grass, intermediate wheat grass and timothy to 0, 9 and 18 kg P ha^{-1} were conducted in northeastern Saskatchewan from 1988 to 1991 (Loeppky et al. 1999).
- Seed yield of all species was significantly increased by P application, except for intermediate wheatgrass.
- Unlike N, which moves relatively freely with water in soil, P is immobile. For this reason, banding of P fertilizer in the soil where it will be directly intercepted by roots is very important.
- Higher rates of P fertilizer can be broadcast and incorporated into soil at forage establishment in soils that are low in available P.

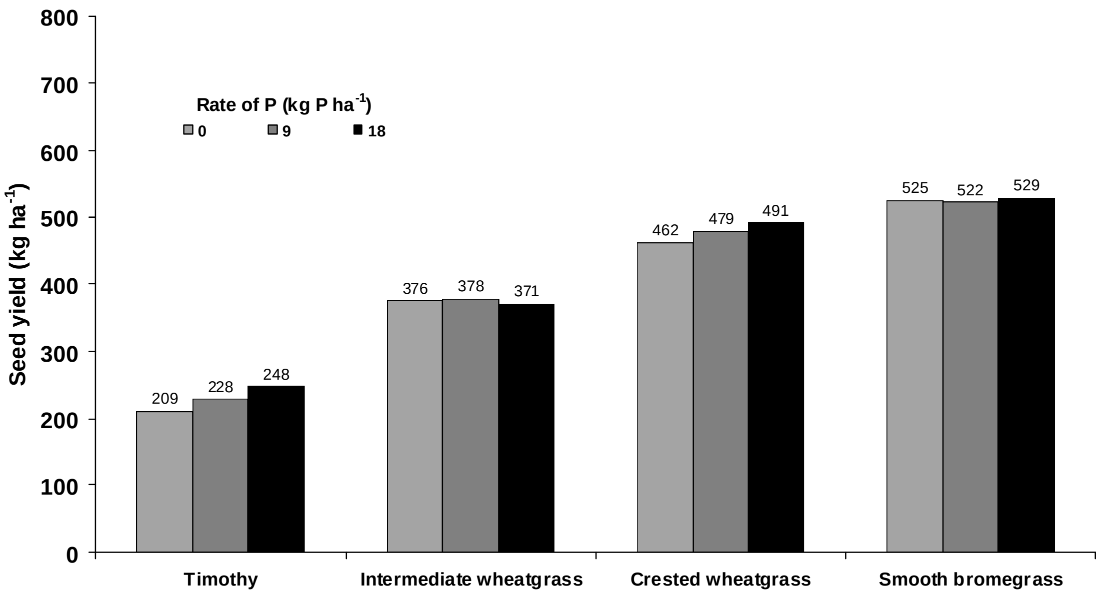

Figure 10. Phosphorus rate effects on seed yield of timothy, intermediate wheatgrass, crested wheatgrass and smooth bromegrass in northeastern Saskatchewan (averaged across N rates from 1989-1991) (prepared from Loeppky et al. 1999).

Effect of Soil Test Nutrient Levels on Seed Yield Response to N Fertilizer

- Magnitude of seed yield increase from N, P and other fertilizers also depends on soil test N, P and other nutrients.

Grasses

- The estimated seed yield response of smooth bromegrass to 50 kg N ha^{-1} ranged from 571 kg ha^{-1} on a soil low in available N to a negative response of –285 kg ha^{-1} on a soil testing high in available N.
- The high correlation of seed yield to soil test data clearly established the significance of nutrient status of the soil in making more precise fertilizer recommendations.

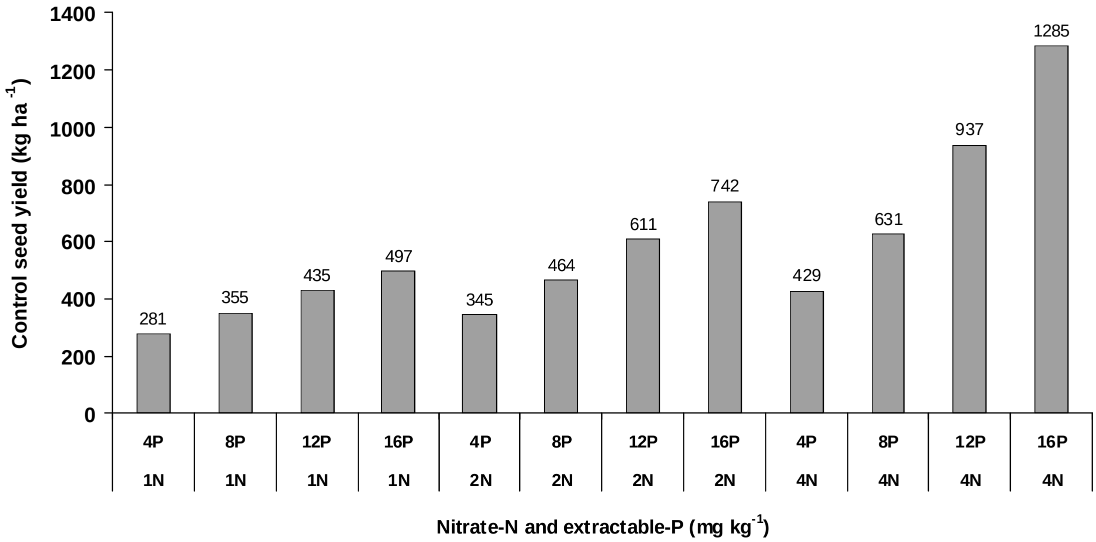

Figure 11. Seed yield of smooth bromegrass in the unfertilizer control plots in relation to soil test nitrate-N (NO_3-N; 0-60 cm) and sodium bicarbonate ($NaHCO_3$) extractable-P (0-15 cm) levels in soil at various sites in northeastern Saskatchewan (prepared from Loeppky et al. 1999).

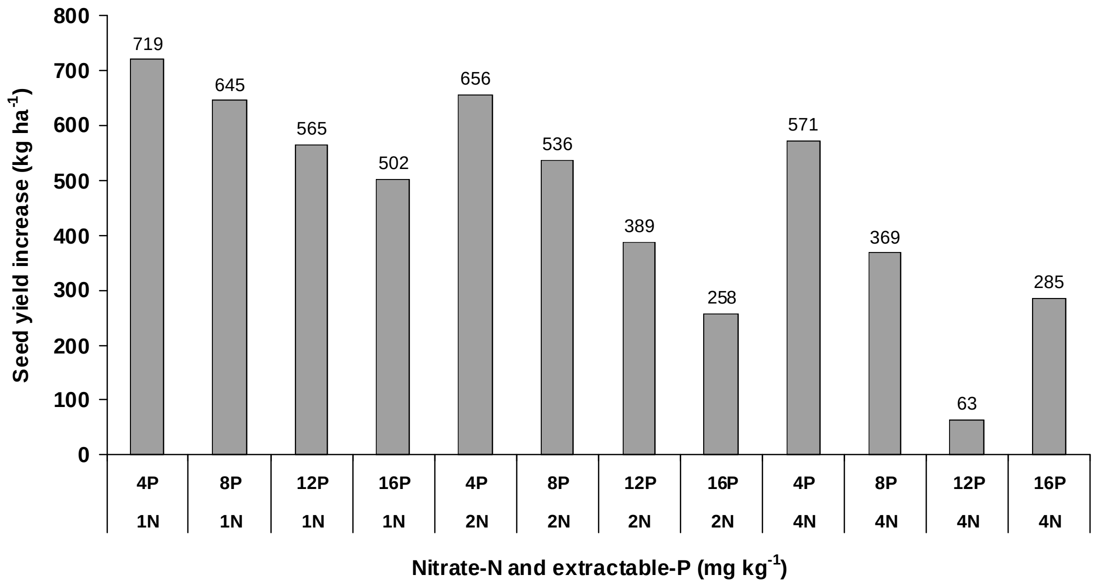

Figure 12. Estimated seed yield increase of smooth bromegrass from N and P fertilizers in relation to soil test nitrate-N (NO_3-N; 0-60 cm) and sodium bicarbonate ($NaHCO_3$) extractable-P (0-15 cm) levels when 50 kg N ha^{-1} plus 9 kg P ha^{-1} were applied at various sites in northeastern Saskatchewan (prepared from Loeppky et al. 1999).

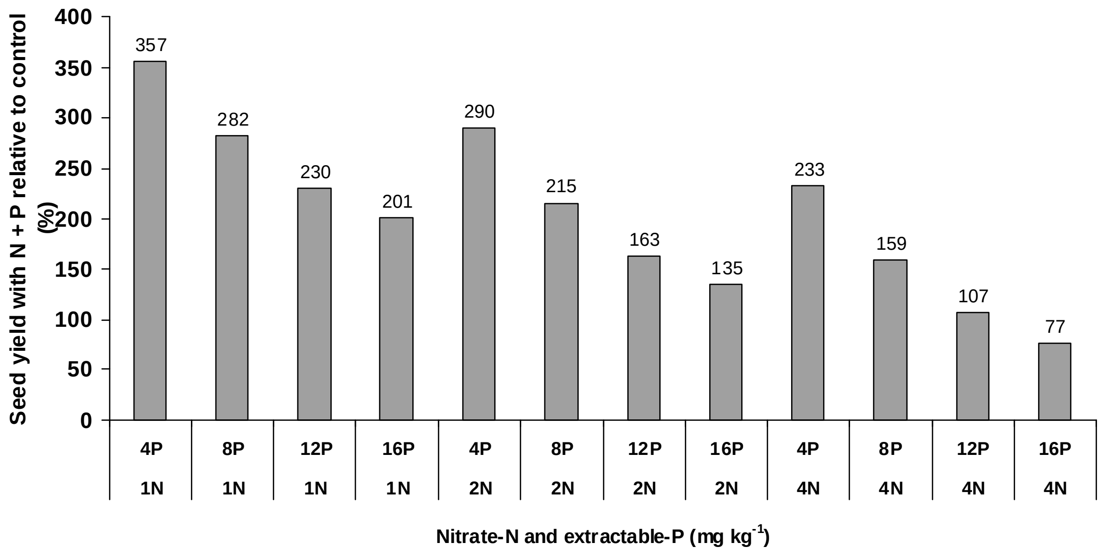

Figure 13. Estimated seed yield in N and P fertilized plots relative to control (%), of bromegrass in relation to soil test nitrate-N (NO_3-N; 0-60 cm) and sodium bicarbonate ($NaHCO_3$) extractable-P (0-15 cm) levels when 50 kg N ha^{-1} plus 9 kg P ha^{-1} were applied at various sites in northeastern Saskatchewan (prepared from Loeppky et al. 1999).

Legumes

- Field experiments in northeastern Saskatchewan were conducted to study the response of alfalfa seed yield to the application of 0, 9, 18, 27 and 54 kg P ha^{-1} from 1988 to 1991.
- The application of P produced a significant increase in seed yield of alfalfa, although the response varied with site.
- For example, the increase of alfalfa seed yield from 20 kg P ha^{-1} was 36 kg ha^{-1} at Eggerman farm (Black soil).
- But little or no increase in seed yield at Newfield and Youzwa farms (Dark Gray soils) because of higher soil test P levels and weather effects.

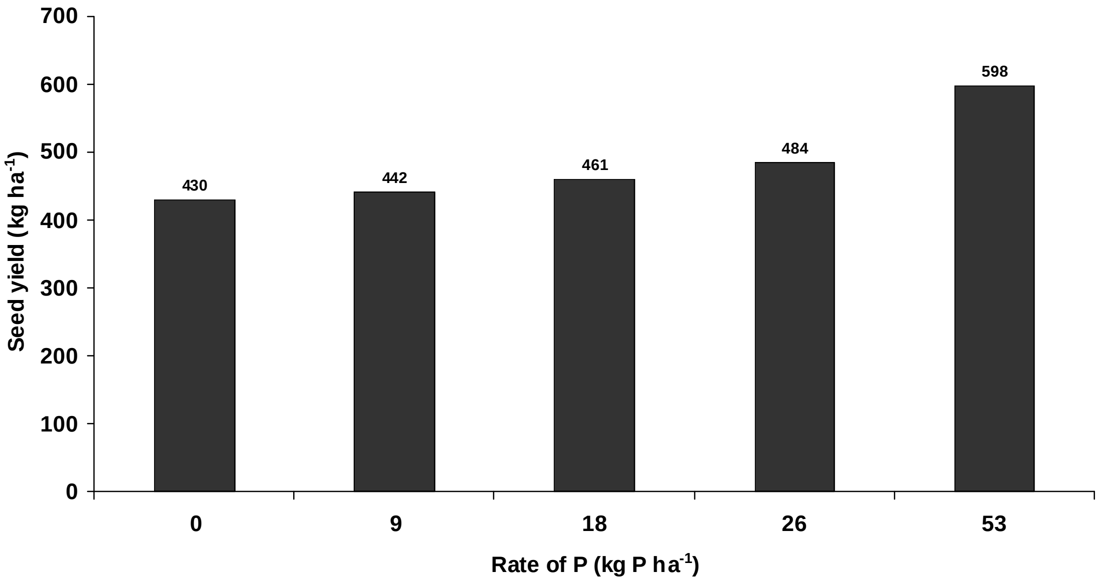

Figure 14. Estimated seed yield of alfalfa with various P fertilizer rates in northeastern Saskatchewan (averaged over 1989 to 1991) (prepared from Loeppky et al. 1999).

Effect of K Fertilizer on Perennial Forage Seed Yield

- Potassium stimulates fixation of N by *Rhizobium* bacteria and decreases the incidence of winter injury in legume stands by increasing the accumulation of carbohydrates in the root system of legumes.
- Under K-deficient conditions, research has shown decline in the legume plant density in long-term stands, thus potentially reducing seed production.
- Potassium is a nutrient that is used in large quantities by most crops (especially when perennial forages are grown for hay production).
- The majority of Saskatchewan soils contain adequate amounts of K for perennial forages, but some coarse-textured (loamy sand and sandy loam) and organic soils are likely to be K deficient.
- On K-deficient soils, perennial forages may benefit from K fertilization.
- Field research information on the seed yield responses of perennial forage grasses and legumes to K fertilization on various soils is lacking.
- When applying K fertilizer, banding is the preferred method of application, and K can be banded with a blend of P fertilizer.

Effect of S Fertilizer on Perennial Forage Seed Yield

- Sulphur (S) is an essential nutrient for N-fixing bacteria, and it affects both yield and quality of seed in legumes and other crops.
- Sulphur is likely to be deficient in many Gray and Dark Gray soils and some coarse-textured Black soils in northeastern Saskatchewan.
- On S-deficient soils, increases in forage seed yields (especially for legumes because of their higher requirements for S than grasses) can be expected from relatively small annual additions of sulphate-S.
- Soils should be tested regularly to insure that an adequate supply of S is available in soil.
- Both legume and grasses will respond to S fertilizer (sulphate form) where S is deficient.
- Sulphate-S is a mobile nutrient and soil testing to the two-foot depth is encouraged.

Effects of P, K and S Fertilizers on Seed Yield of Alfalfa in Other Studies

- Horton 1991 Report – P and S field experiments from 1988-1990
- There was no increase in seed yield of alfalfa from P and S fertilization, because most soils in the experiments had adequate levels of P and S for optimum seed yield (extractable P in 0-15 cm soil 32-36 kg P ha^{-1} and sulphate-S in 0-60 cm soil 43-81 kg S ha^{-1}).
- Gossen et al. 2004. CJPS 84: 1105-1108 – P, K and S field experiment from 1986-1993 (Saskatoon)
- Seed yields were excellent (> 400 kg ha^{-1} in most cases) and application of P, K and S fertilizers had little or no impact on seed yield. This was due to adequate initial soil fertility (0-15 cm soil had 41 mg P kg^{-1}, 353 mg K kg^{-1} and 15 mg S kg^{-1}). So, no need for additional fertilizer nutrients to maintain high level of seed production.

Effect of Micronutrient Fertilizers on Seed Yield

- Most soils in Saskatchewan are adequately supplied with micronutrients and deficiencies of micronutrients are rare.
- In the few field studies conducted in Saskatchewan, seed yield responses to micronutrient fertilizers were small and inconsistent. Therefore, no general conclusions can be drawn.
- In order to determine which micronutrient is limiting in soil, soil and tissue testing is suggested.
- In addition, it is important for producers to try on-farm testing in small areas to determine seed yield responses to micronutrient fertilizers before making major changes in overall fertilizer programs.

Main Points to Consider When Fertilizing Perennial Forages for Seed Production:

- Soil test (to soil depth 60 cm for N and S, and 15 cm for P and K) to find if any nutrients lacking in the soil and fertilize accordingly.
- Whenever possible, band the fertilizers (particularly P, K and urea for N) into the soil for most efficient use of the nutrients. Alternatively, higher rates of P and K may be broadcast and incorporated into the soil prior to seedbed preparation.
- Nitrogen management produces the greatest grass seed yield increases but will not increase yield if P, K, and S are limiting, or out of balance.
- The best N source for surface-broadcast application is ammonium nitrate (34-0-0), because it is highly soluble in water and readily moves with soil moisture to roots for rapid uptake (but it may not be widely available in the market).
- Although urea (46-0-0) is highly soluble in water, it is vulnerable to N loss through ammonia volatilization when surface applied and thus less N may be available to the crop. So, time of application in relation to rainfall and placement method are important for urea fertilizer.
- Because grasses efficiently absorb water from soil, the risk of N leaching or gaseous N loss by denitrification is usually minimal.

- All N sources can be equally effective when applied just prior to rainfall or below the soil surface.
- Time of N application is critical and fall application is recommended for many grass species, as spring application has shown to stimulate vegetative growth over culm formation.
- Inoculation of seed with correct strain of *Rhizobium* is critical for producing a healthy stand for legume forage seed production.
- For legumes, focus on correcting P, K and S deficiencies for legumes (as N fertilizer is not needed).

Other Points to Consider

✓ Stand age, population and unproductive tillers.
✓ Residue management (removal vs. returning).
✓ Forage crop harvested for hay or seed

Acknowledgements

Thanks to Darwin Leach for technical help in the preparation of this document.