Legume and Native Shrub Mixtures for Potential Optimum Forage Production

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Introduction

Late season grazing has been identified as a method of decreasing the cost of beef production in southwestern Saskatchewan. Late season grazing can be improved by utilizing native shrub and legume species which maintain higher nutritional quality in the fall. In order to develop a potential forage source with these species requires clearer understanding of optimum mixtures of legumes and shrubs. A greater understanding of the processes occurring in the soil environment and impact on plant biomass is also required. The objective therefore of this project is:

(i) to optimize mixtures of legumes and shrubs for economical production of pasture,
(ii) to obtain better understanding of synergy from combinations of native forage shrubs and legumes to further improve their productivity, and,
(iii) to monitor the changes in soil quality caused by growing legumes and shrubs in monocultures or mixtures.

Materials and Methods

Field Plot Study

A field study was initiated to optimize mixtures of legumes and shrubs for economical pasture production. This research consists of two different emphases. The first emphasis is to determine the appropriate mixture of legumes and shrubs. The second emphasis is to determine the changes occurring within the soil caused by growing the combinations of legumes and shrubs. Legumes species studied were: alfalfa (*Medicago sativa*), purple prairie clover (*Petalostemon purpureum*) and american vetch (*Vicia americana*); shrubs were: winterfat (*Ceratoides lanata*) and salt bush (*Atriplex nuttallii*). Treatments were applied to plots arranged in a randomized complete block design (Figure 1). Total number of treatment plots is forty eight. Each plot is 9 m X 3 m with two rows of legume and/or shrub transplanted with well established Russian wildrye in rows on either side of legume/shrub combinations. All plots were

rototilled before transplanting (May 29, 1998) shrub seedling or seedling legumes. Treatments consist of five monocultures, six combinations and a control; with four replications. The treatments were:

1. Alfalfa (Alf)
2. Purple Prairie Clover (Pr Cl)
3. American Vetch (Vetch)
4. Winterfat (Wf)
5. Saltbush (Sb)
6. Alfalfa + Winterfat (Alf + Wf)
7. Alfalfa + Saltbush (Alf + Sb)
8. Purple Prairie Clover + Winterfat (Pr Cl + Wf)
9. Purple Prairie Clover + Saltbush (Pr Cl + Sb)
10. American Vetch + Winterfat (Vetch + Wf)
11. American Vetch + Saltbush (Vetch + Sb)
12. Control treatment - no seedlings in strip

Plot 1 **Wf** + Alf	**Plot 13** **Winterfat (Wf)**	Plot 25 Sb + Alf	Plot 37 Alfalfa (Alf)
Plot 2 Sb + Alf	Plot 14 Vetch	Plot 26 Sb + Pr Cl	**Plot 38** **Winterfat (Wf)**
Plot 3 **Winterfat (Wf)**	Plot 15 Alfalfa (Alf)	Plot 27 Alfalfa (Alf)	Plot 39 Sb + Vetch
Plot 4 Sb + Vetch	Plot 16 *Control*	**Plot 28** **Wf** + Alf	Plot 40 Prairie Clover (Pr Cl)
Plot 5 **Wf** + Vetch	Plot 17 Saltbush (Sb)	Plot 29 Prairie Clover (Pr Cl)	**Plot 41** **Wf** + Vetch
Plot 6 Vetch	Plot 18 Sb + Alf	Plot 30 Sb + Vetch	Plot 42 *Control*
Plot 7 **Wf** + Pr Cl	**Plot 19** **Wf** + Pr Cl	**Plot 31** **Wf** + Pr Cl	**Plot 43** **Wf** + Pr Cl
Plot 8 Alfalfa (Alf)	**Plot 20** **Wf** + Vetch	**Plot 32** **Wf** + Vetch	Plot 44 Saltbush (Sb)
Plot 9 Saltbush (Sb)	Plot 21 Prairie clover (Pr Cl)	**Plot 33** **Winterfat (Wf)**	Plot 45 Sb + Pr Cl
Plot 10 Prairie clover (Pr Cl)	**Plot 22** **Wf** + Alf	Plot 34 Saltbush (Sb)	Plot 46 Sb + Alf
Plot 11 Sb + Pr Cl	Plot 23 Sb + Pr Cl	Plot 35 Vetch	Plot 47 Vetch
Plot 12 *Control*	Plot 24 Sb + Vetch	Plot 36 *Control*	**Plot 48** **Wf** + Alf

Figure 1. Experimental design of the legume-shrub field plot study

Plant mortality, total forage production, forage quality, soil moisture and changes in soil quality parameters were monitored. Initial soil characterization was done (Table 1). Soil moisture content was monitored every two weeks initially and later on a monthly basis by Time Domain Reflectometer.

Table 1. Physical and Chemical Characteristics of South Farm Soil at the Legume-Shrub Study Site.

Texture		**Sandy loam**
	Sand (%)	**65.4**
	Silt (%)	**21.1**
	Clay (%)	**13.5**
pH		**6.61**
EC (dS $^{-1}$)		**0.54**
Total C (g 100g^{-1})		**1.93**
Organic C (g 100g^{-1})		**1.84**
	Organic C as % of Total C	**95.13**
Total Nitrogen (g 100g^{-1})		**0.2**
	NH_4-N (Fg g^{-1})	**2.95**
	NO_3-N (Fg g^{-1})	**1.76**
C : N		**9.84**
Extractable P (Fg g^{-1})		**5.8**
Extractable K (Fg g^{-1})		**457.54**
Extractable S (Fg g^{-1})		**3.67**

Greenhouse Pot Study

Soils were collected from the same site as the field study (South Farm, Swift Current). A simulated pot study was conducted in the green house (16 hour photo period, 8 hour dark) using the same 12 treatments as the field study. However, the number of replications per treatment was three to give a

total number of thirty-six pots for the experiment. Each pot contained 2 kg of soil. Shrubs and legumes were transplanted into the appropriate pots in the last week of August, 1998.
The seedlings came from the same seed lots as the field experiment. Four plants were transplanted into each pot. The pots contained 4 plants of a single species for monocultures and for the mixture treatments, 2 plants per selected species. Plant biomass was measured as fresh and dry weights at five consecutive harvests. At the fifth harvest soils were destructively sampled to assess the changes in the soil parameters.

Results and Discussion

Establishment and growth of legume/shrub plants in the field at different growth stages were visually observed. Although the initial establishment of the shrub/legume plants were acceptable, by fall vetch and saltbush were struggling to grow. In general, growth of the plants were poor in the initial year of field study most probably due to the very dry growing season. As a result, biomass determination was not done. Although it is too early to find any significant observation, there are only visual indications that the plant mixtures might be growing better than the monocultures.

Establishment and growth of shrub/legume plants in the pots at different growth stages were visually observed. In the pot study, based on the five cuts, the mixture treatments in general produced more biomass than the monocultures (Figure 2). However, the Pr Cl + Wf and Vetch + Sb treatments did not enhance the biomass production compared to the combined production of their respective monoculture treatments. In the Alf + Wf and Alf + Sb treatments, production of alfalfa was increased to the extent that even though the production of winterfat and saltbush have been decreased the total production of the combinations were higher than the monocultures (Figure 2). In addition, only Alf + Wf and Alf + Sb treatments showed positive or no negative impact on the biomass production on oven dry weight basis (Figure 3). The Pr Cl + Sb and Vetch + Sb combination produced more shrub (saltbush) compared to the respective legumes. Although the production was not as high as Alf + Wf or Alf + Sb combinations, however, these observation might have a bearing on the composition of the forage stands (Figures 2 and 3).

Forage quality (protein yield and P content) were increased or nearly maintained at the same level in the Alf + Wf and Alf + Sb treatments compared to the combined forage quality of their respective monoculture treatments (Figures 4 and 5).

No significant changes were found at this time in soil quality parameters measured by growing legumes and shrubs in mixtures in the pots (Table 2).

Conclusion

The study indicates that a pasture with a mixture of shrubs and legumes (Alf + Wf and/or Alf + Sb) can potentially provide diversified forage source, extended grazing periods, produce higher yields than when grown separately with enhanced or similar forage quality. However, long-term field study is needed before the true benefit can be established satisfactorily.

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Table 2. Soil Parameters* after the 5th Harvest in the Legume-Shrub Pot Study.

Treatment	Total C ($g\ 100\ g^{-1}$)	Organic C ($g\ 100\ g^{-1}$)	Organic C as % of total C (%)	Total N ($g\ 100\ g^{-1}$)	C : N
Control	**1.58 ± 0.10**	**1.55 ± 0.07**	**98.17 ± 2.03**	**0.16 ± 0.01**	**9.67 ± 0.18**
Alfalfa (Alf)	**1.54 ± 0.04**	**1.51 ± 0.05**	**98.26 ± 0.80**	**0.15 ± 0.01**	**9.88 ± 0.47**
Winterfat (Wf)	**1.69 ± 0.11**	**1.66 ± 0.11**	**98.02 ± 0.71**	**0.16 ± 0.01**	**10.40 ± 0.12**
Saltbush (Sb)	**1.99 ± 0.31**	**1.89 ± 0.24**	**95.41 ± 3.19**	**0.17 ± 0.01**	**11.30 ± 0.94**
Alf + Wf	**1.62 ± 0.10**	**1.58 ± 0.12**	**97.49 ± 1.25**	**0.16 ± 0.01**	**10.10 ± 0.42**
Alf + Sb	**1.71 ± 0.06**	**1.66 ± 0.10**	**97.02 ± 3.16**	**0.16 ± 0.01**	**10.20 ± 0.96**

*****Values are mean of four replications ± Standard deviation