Optimum seeding rates for three annual green manure crops: the effect of weed competition

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Abstract

Green manure crops are critical to maintaining soil fertility in organic cropping systems. However, little research has been conducted to address their contribution to weed control. Indian Head black lentil (*Lens culinaris*), AC Green Fix chickling vetch (*Lathyrus sativus*), and Trapper field pea (*Pisum sativum*) are legumes developed for use as annual green manure crops in Saskatchewan. Currently, the recommended seeding rates for these crops are based on those developed for seed production of similar genotypes under weed-free conditions. Thus, our objective was to determine the optimal seeding rates for these three annual green manure crops under weedy and weed free conditions. The competitive ability of the green manure crops was assessed based on their ability to maintain crop biomass and reduce weed biomass. Each green manure crop was grown at five plant population densities (10, 26, 64, 160, and 400 plants m^2) with weedy and weed free treatments. Wild oat (*Avena fatua*) and wild mustard (*Brassica kaber*) were planted in the weedy treatment to supplement the natural weed community. Biomass samples were taken at early bud and full bloom stages to simulate when these crops would be terminated. Trapper field pea produced the most crop biomass while Indian Head black lentil and AC Green Fix chickling vetch produced comparable amounts of crop biomass under both weedy and weed-free conditions. While Trapper field pea produced more crop biomass than AC Green Fix chickling vetch, weed biomass was similar for both species. Weed biomass was highest for Indian Head black lentil. Total biomass increased between the early bud and full bloom biomass dates for all species. However, weed biomass as a proportion of total biomass increased more than crop biomass between early bud and full bloom in weedy treatments. Recommended seeding rates developed from this experiment will help organic producers take advantage of the weed control offered by a competitive annual green manure while still achieving their objectives of improved soil nutrient status and soil quality.

Introduction

Green manure crops are grown for the purpose of incorporating their biomass into the soil. There are several terms used to describe these types of crops including cover crops, green fallow, or plow down crops. Although green manure crops are not commonly used in conventional farming, they are an essential part of organic cropping systems. A survey of Saskatchewan organic farms in 2002 indicated that 46% had grown green manure crops within the last five years (Shirtliffe and Knight 2003). Reasons for the inclusion of green manure crops in crop rotations include increased availability of soil nutrients, reduced soil erosion, increased soil organic matter, reduced nutrient leaching, increased microbial activity, and to provide weed control (Biederbeck et al. 1993, Biederbeck et al.1995, Biederbeck et al. 1998, Brandt 1996, Rice et al. 1993). Most of the benefits to green manure crops are related to soil nutrients and soil quality, and thus most research has focused on these aspects. Although weed control is often viewed as the number one challenge to organic crop production, little research has been conducted specifically looking at green manure crops as a weed control tool.

One of the agronomic problems of green manure crops identified by Biederbeck et al. (1993) was poor competition with weeds. To minimize this problem, producers need to establish a competitive green manure stand by growing a competitive species at a high enough density. Without their own personal experience to determine these optimally high green manure seeding rates, producers are reliant on seeding rate studies conducted for seed production of similar genotypes under weed-free conditions. These studies may not prove to be relevant for organic producers trying to grow green manure crop varieties under weedy conditions.

This study examines three annual green manure crops that have been developed as fallow replacements for dry areas of the Northern Great Plains, where moisture conservation is an important issue. These three species are Trapper field pea (*Pisum sativum*), AC Green Fix chickling vetch (*Lathyrus sativus*), and Indian Head black lentil (*Lens culinaris*). The objectives of this study were three fold. Firstly, to compare the competitive abilities of Trapper field pea, AC Green Fix chickling vetch, and Indian Head black lentil with weeds. Secondly, to determine the optimum seeding rate for these three annual green manure species under both weedy and weed-free conditions. Thirdly, to determine if the optimal green manure plow down-date is influenced by crop-weed competition.

Materials and Methods

A three factor split plot design was set up with weed treatment (weedy or weed-free) as the main plot. Each combination of three species (Trapper field pea, AC Green Fix chickling vetch, and Indian Head black lentil) and five densities (10, 24, 64, 160, 400 pl/m^2) were fully randomized within the main plots as sub plots. Wild oat (*Avena fatua*) and wild mustard (*Brassica kaber*) were planted in the weedy treatment to supplement the natural weed community. Three experiments were run in 2003, two of them at the same site, all within the Dark Brown Soil zone of Saskatchewan, near Saskatoon. Measurements taken included crop and weed plant population densities, as well as crop and weed biomass at early bud and full bloom plow down stages. Non-linear analysis of the data was used to account for actual plant population densities.

Results and Discussion

Figures 1, 2, and 3 show the accumulation of biomass as plant population density increases for weedy treatments of Trapper field pea, AC Green Fix chickling vetch, and Indian Head black lentil respectively. The points on these graphs represent observed yields at actual measured plant population densities from three sites. The curves were fitted using the indicated equations found in each graph. Biomass increased for each species between early bud and full bloom across all seeding rates, but not very dramatically. Trapper field pea produces the most biomass, followed by AC Green Fix chickling vetch and Indian Head black lentil.

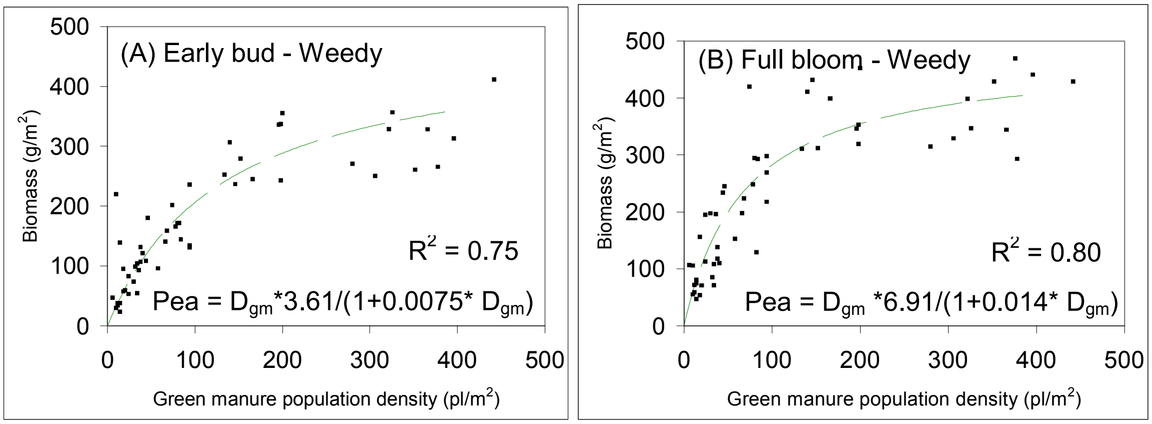

Figure 1. Effect of seeding rate on biomass accumulation in Trapper field pea under weedy conditions at (A) early bud and (B) full bloom.

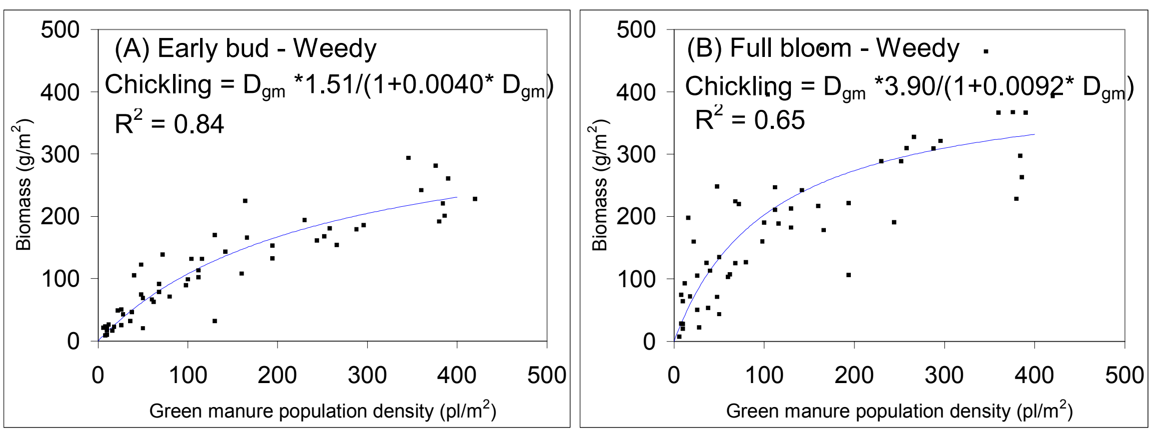

Figure 2. Effect of seeding rate on biomass accumulation in AC Green Fix chickling vetch under weedy conditions at (A) early bud and (B) full bloom.

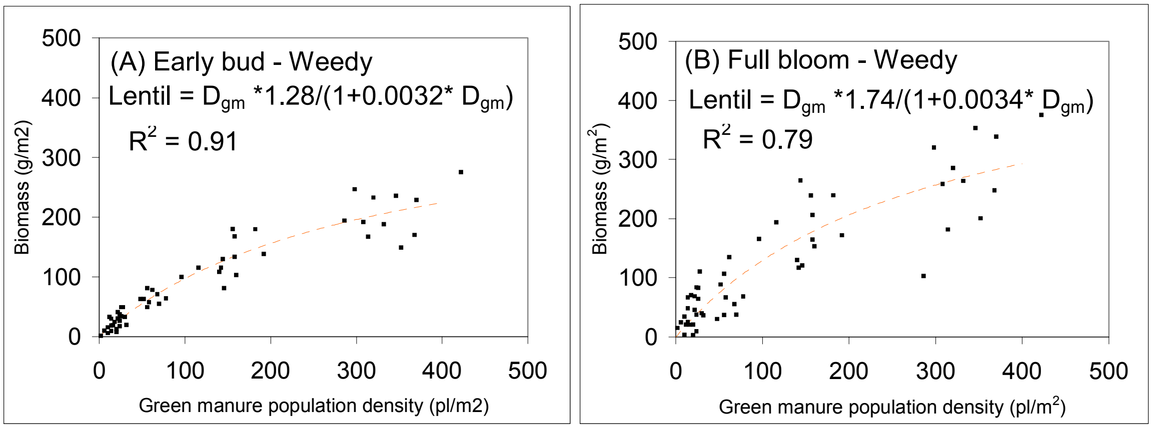

Figure 3. Effect of seeding rate on biomass accumulation in Indian Head black lentil under weedy conditions at (A) early bud and (B) full bloom.

Figure 4 summarizes the last three figures showing only the fitted curves and compares the weedy and weed-free treatments for all three species. Trapper field pea produces the most biomass under weedy conditions. AC Green Fix chickling vetch and Indian Head black lentil produce similar biomass when terminated at early bud. When left to compete with weeds until full bloom, AC Green Fix chickling vetch significantly out produces Indian Head black lentil. However, under weed-free conditions, we do not see this differential yield between AC Green Fix chickling vetch and Indian Head black lentil between early bud and full bloom.

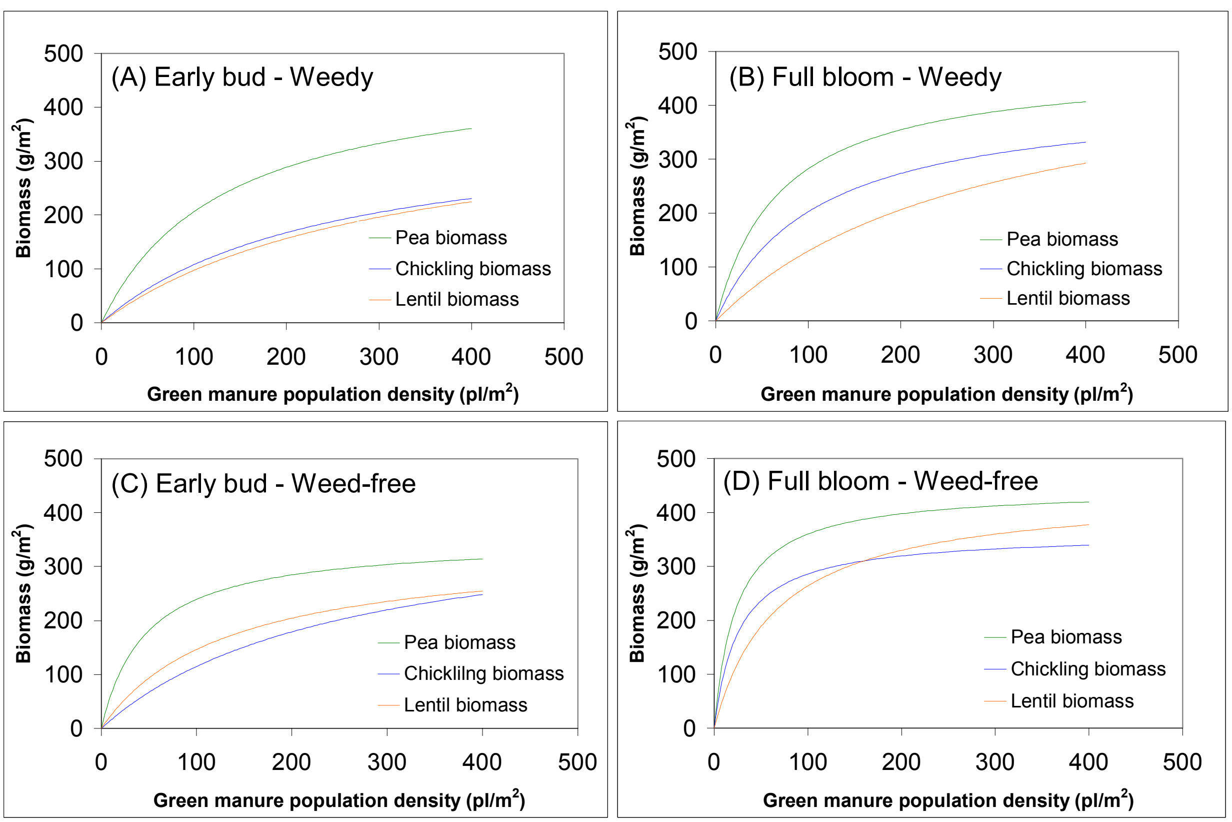

Figure 4. Effect of seeding rate on biomass accumulation in Trapper field pea, AC Green Fix chickling vetch, and Indian Head black lentil for (A) Early bud - Weedy (B) Full bloom – Weedy (C) Early bud - Weed-free (D) Full bloom - Weed-free

When comparing the shape of the biomass yield curves between weed treatments, only the weed-free treatments are reaching a point of constant final yield. Even at 400 pl/m2 under weedy conditions the three green manure crops have not reached their asymptotes. This indicates that higher seeding rates are needed under weedy conditions.

As looking at the effect of crop density and weed treatment on green manure biomass yield is only half of the story, Figures 5, 6, and 7 show the effect of green manure crop density on weed biomass production. These figures are based on data from three sites. The points on the graphs represent observed yields at actual measured plant population densities. The curves were fitted using the indicated equations found in each graph. As expected, increasing green manure plant population density results in decreasing weed biomass. Also, weed biomass increases between early bud and full bloom. This increase in weed biomass between the two harvest dates is more significant than the increase in crop biomass. This trend is consistent amongst all three crops and suggests that under weedy conditions, early incorporation results in a greater proportion of nitrogen fixing biomass.

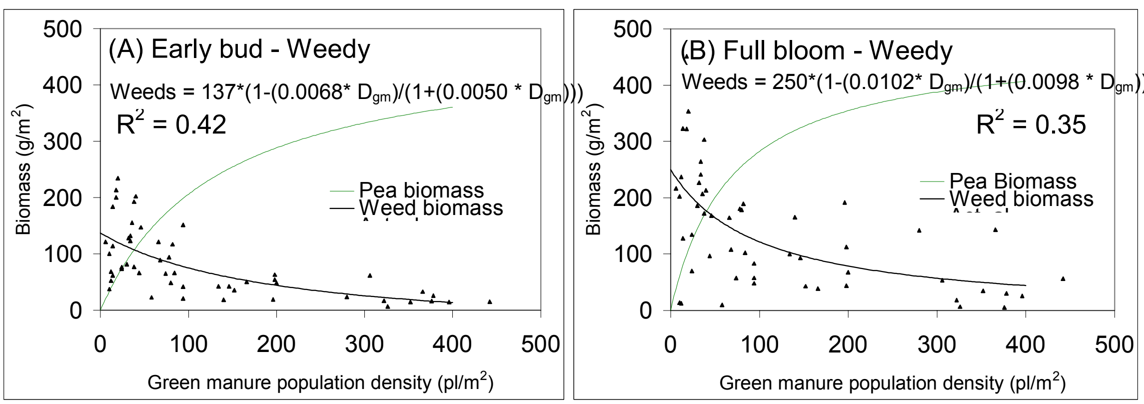

Figure 5. Effect of Trapper field pea seeding rate on weed biomass accumulation at (A) early bud and (B) full bloom.

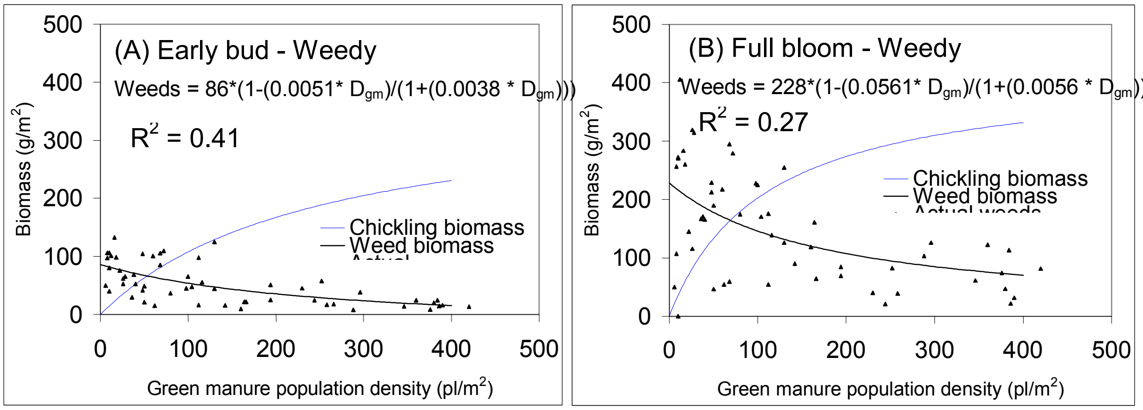

Figure 6. Effect of AC Green Fix chickling vetch seeding rate on weed biomass accumulation at (A) early bud and (B) full bloom.

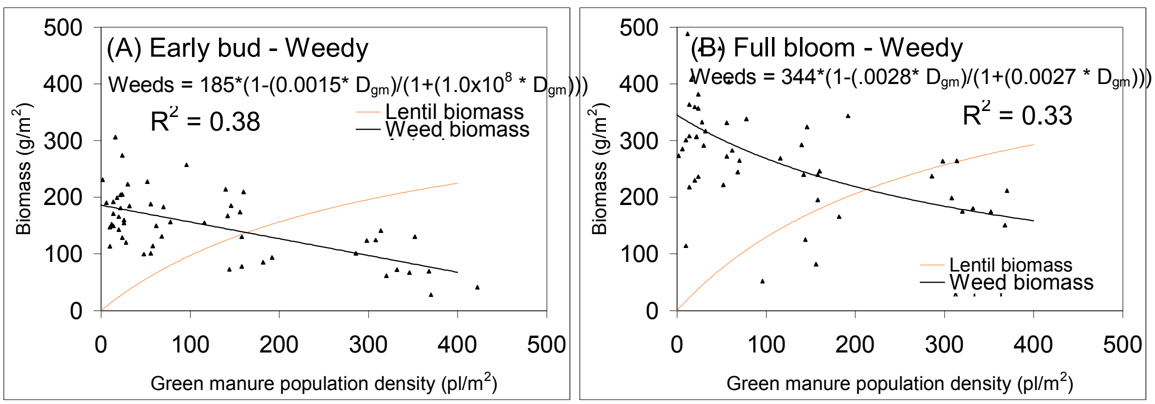

Figure 7. Effect of Indian Head black lentil seeding rate on weed biomass under weedy conditions at (A) early bud and (B) full bloom.

Weed biomass is highest for Indian Head black lentil and lowest for Trapper field pea and AC Green Chickling vetch. AC Green Fix chickling vetch is able to suppress weeds with less biomass compared to Trapper field pea. This may be an important observation for producers in dry areas that are concerned about weed control and moisture conservation when choosing a green manure crop.

To develop meaningful seeding rate recommendations from this research, the data discussed above should be compared to their relative seed costs. Figure 8 compares the relative cost to produce a range of green manure crop biomass based on the 2003 seed costs for Indian Head black lentil ($0.30/lb), Trapper field pea ($0.22/lb), and AC Green Fix chickling vetch ($0.32/lb). Chickling vetch is by far the most expensive way to accumulate biomass because of its large seed size relative to Indian Head black lentil and Trapper field pea. Further total nitrogen analysis of plant biomass will indicate if the extra expense of growing chickling vetch is warranted in terms of its ability to fix more nitrogen (Biederbeck et al. 1996).

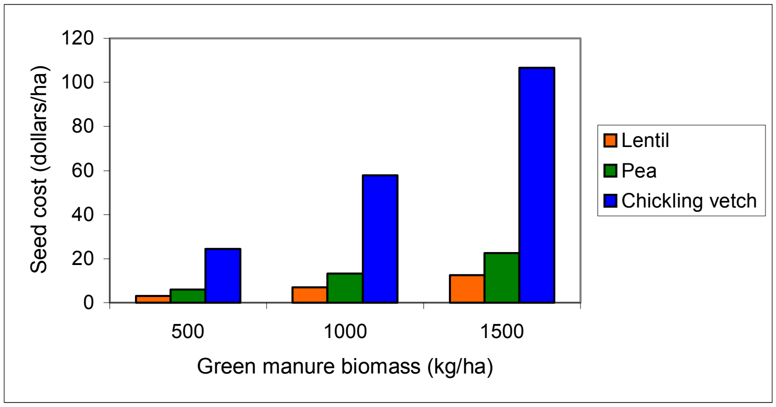

Figure 8. Seed cost to produce specific amounts of biomass for Indian Head black lentil, Trapper field pea, and AC Green Fix chickling vetch in 2003.

Conclusions

Trapper field pea had the highest biomass production under both weedy and weed-free conditions. Both Trapper field pea and AC Green Fix chickling vetch suppressed weed growth better than Indian Head black lentil. Indian Head black lentil competed poorly with weeds, especially when grown to the full bloom stage. This study indicates that green manure crop termination at early bud increases the proportion of crop biomass relative to weed biomass under weedy conditions. Also, under weedy conditions it is necessary to increase green manure seeding rates. Economic analysis taking into account seed costs is needed to develop specific seeding recommendations.

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