Relative Effectiveness of Various Amendments in Improving Yield and Nutrient Uptake under Organic Crop Production

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Introduction

- In organic farming, inorganic fertilizers/chemicals are not applied to prevent nutrient deficiencies in crops to increase production, but adequate amounts of nutrients are essential for sustainable production.
- In the Canadian Prairies, most organically farmed soils are deficient in available N, many soils low in available P, and some soils contain insufficient available S and K for optimum crop yield.
- The N deficiency in soil on organic farms can be minimized by growing/green manuring N-fixing legume crops, but if soils are deficient in available P, K, S or other essential nutrients, the only alternative is to use external amendments to prevent these nutrient deficiencies.
- Manure/compost can provide these nutrients, but often there is not enough manure or it is uneconomical to apply manure in remote areas. On such soils, rock phosphate fertilizer, elemental S fertilizer, gypsum, wood ash or other amendments may be used to correct deficiencies of these nutrients.
- The information on the efficacy of organic nutrient sources in improving yield by preventing nutrient deficiencies in organic crops is lacking under prairie soil-climatic conditions.

Objective

To determine the feasibility of compost, alfalfa pellets, wood ash, *Penicillium bilaiae*, rock phosphate, gypsum, and MykePro in increasing yield, seed quality and nutrient uptake by preventing N, P, K or S deficiencies in crops grown on certified organic farms.

Materials and Methods

- Two 3-year (2008 - wheat, 2009 – pea, and 2010 - barley) field experiments were established on certified organic farms in spring 2008. During the summer of 2007, the land was managed as tilled fallow in **Experiment 1 at Naicam**, and as green manure fallow in **Experiment 2 at Star City**.
- Precipitation in the growing season (May, June, July and August) was below average, with little precipitation in May at both sites in 2008. The precipitation in the 2009 growing season was slightly above average, with little precipitation in May at Naicam, and near average, with low precipitation in May at Star City.
- Amendments were broadcast on surface and all plots were rotovated to about 10 cm soil depth few days prior to seeding. Plots were seeded with a double-disc press drill at 17.8 cm row spacing.

- Data were collected on seed yield, total biomass yield, and total N, P, K and S in seed and straw.

Experiment 1 (South of Naicam) - treatments were:

1. Control (no amendment)
2. Compost @ 10 Mg ha^{-1}
3. Compost @ 20 Mg ha^{-1}
4. Compost @ 30 Mg ha^{-1}
5. Wood ash @ 1 Mg ha^{-1}
6. Wood ash @ 2 Mg ha^{-1}
7. Wood ash @ 3 Mg ha^{-1}
8. Rock phosphate granular @ 10 kg P ha^{-1}
9. Rock phosphate granular @ 20 kg P ha^{-1}
10. Rock phosphate granular @ 30 kg P ha^{-1}
11. Rock phosphate finely-ground @ 10 kg P ha^{-1}
12. Rock phosphate finely-ground @ 20 kg P ha^{-1}
13. Rock phosphate finely-ground @ 30 kg P ha^{-1}
14. Alfalfa pellets @ 1 Mg ha^{-1}
15. Alfalfa pellets @ 2 Mg ha^{-1}
16. Alfalfa pellets @ 4 Mg ha^{-1}
17. Alfalfa pellets @ 6 Mg ha^{-1}
18. Control + Inoculate seed with *Penicillium bilaiae*,
19. Rock phosphate granular @ 20 kg P ha^{-1}+*Penicillium bilaiae*
20. Rock phosphate finely-ground @ 20 kg P ha^{-1}+*Penicillium bilaiae*
23. MykePro

Experiment 2 (South of Star City) - treatments were:

1. Control (no amendment)
2. Compost @ 10 Mg ha^{-1}
3. Compost @ 20 Mg ha^{-1}
4. Compost @ 30 Mg ha^{-1}
5. Wood ash @ 1 Mg ha^{-1}
6. Wood ash @ 2 Mg ha^{-1}
7. Wood ash @ 3 Mg ha^{-1}
8. Alfalfa pellets @ 1 Mg ha^{-1}
9. Alfalfa pellets @ 2 Mg ha^{-1}
10. Alfalfa pellets @ 4 Mg ha^{-1}
11. Alfalfa pellets @ 6 Mg ha^{-1}
12. Gypsum @ 10 kg S ha^{-1}
13. Gypsum @ 20 kg S ha^{-1}
16. Control + *Penicillium bilaiae*
17. Rock phosphate finely-ground @ 20 kg P ha^{-1}
18. Rock phosphate finely-ground @ 20 kg P ha^{-1} +*Penicillium bilaiae*
19. Rock phosphate granular @ 20 kg P ha^{-1}
20. Rock phosphate granular @ 20 kg P ha^{-1} +*Penicillium bilaiae*
21. MykePro

Summary

Experiment 1:

- In 2008, seed yield and total biomass yield (TBMY) of wheat increased with compost and tended to increase with alfalfa pellets, but in other treatments similar to the control.
- In 2009, there was no significant increase in seed yield of pea from any amendment, suggesting that organic amendments were not effective in improving yield of pea. The TBMY showed increases in some treatments, but the differences were not significant.
- In 2010, seed yield of barley increased considerably with alfalfa pellets and compost, and moderately with wood ash, but no effect in other treatments.
- In 2008, total N uptake in seed and seed + straw of wheat increased with alfalfa pellets and compost, but in straw it increased only with alfalfa pellets, suggesting that N in some treatments became available to the crop in the first year of application. Total P, K, or S uptake in seed and seed + straw increased with alfalfa pellets and compost, but the increases were small.
- In 2009, there was no effect of any amendment treatment on total N uptake in seed. Total N uptake in straw or seed + straw was highest with compost, suggesting that N in compost became available to the crop, but it apparently did not benefit seed yield. Total P, K, or S uptake in seed, straw, or seed + straw was highest with compost, suggesting that these nutrients became available to the crop from compost.

Experiment 2:

- In 2008, seed yield and TBMY of wheat increased with compost and alfalfa pellets compared to the zero-amendment control, but no beneficial effect from other treatments.
- In 2009, seed yields of pea increased only with compost, and there was a good response of TBMY to compost and alfalfa pellets.
- In 2010, seed yield of barley increased considerably with alfalfa pellets, followed closely by compost, with moderate increase by wood ash, but no effect in other treatments.
- In 2008 and 2009, total N, P, K, or S uptake in seed, straw and seed + straw increased with compost and alfalfa amendment treatments, suggesting that nutrients in compost or alfalfa pellets became available to the crop in the growing seasons.

Conclusions

- Compost and alfalfa pellets increased crop yield and/or nutrient uptake, but rock phosphate, *Penicillium bilaiae*, wood ash and MykePro had little effect on crop yield and/or nutrient uptake.
- In summary, the results suggest the potential of some organic amendments in improving yield and nutrient uptake, most likely by preventing some nutrient deficiencies in organic crops.

- However, on the potentially P-deficient soil in Experiment 1, we expected seed yield increase from finely-ground rock phosphate, *Penicillium bilaiae*, or MykePro, but it did not happen.
- This was probably that the soil contained enough available P for organic crop production with low yield potential. Similarly, on the potentially S-deficient soil in Experiment 2, we also expected seed yield increase with gypsum, but it did not occur.
- Again, this was probably that the soil contained enough available S for organic crop production with low yield potential.

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Figure 1 Seed yield, of wheat with various amendments applied in spring 2008, at Naicam, Saskatchewan (P-deficient soil – Experiment 1 established in spring 2008)

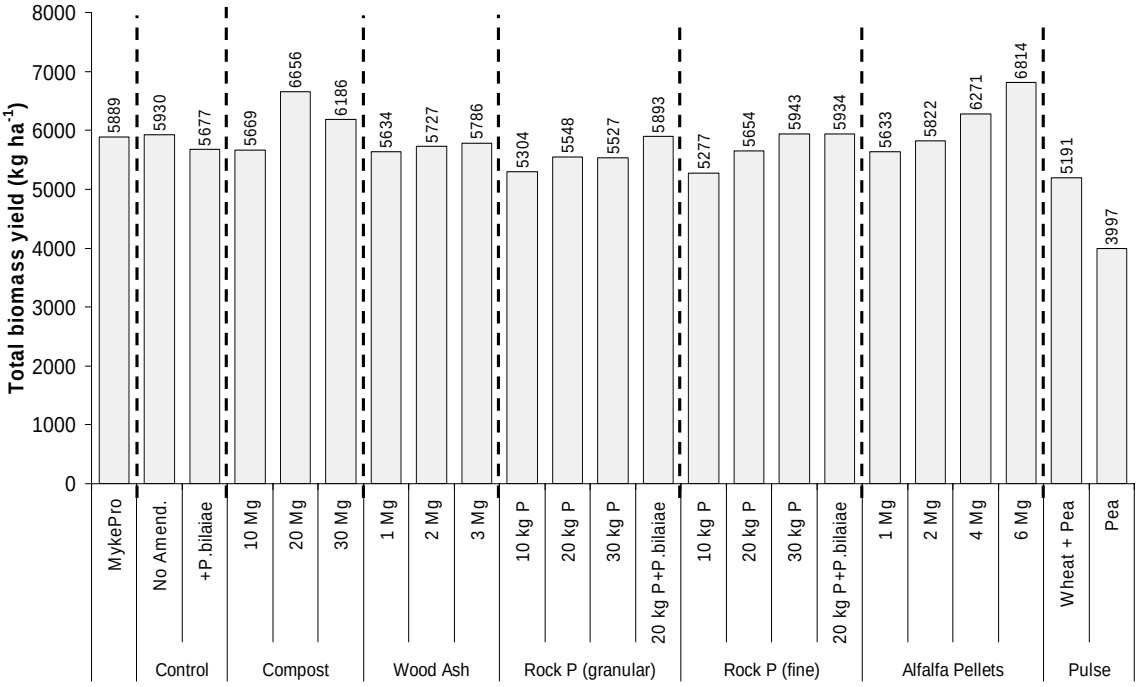

Figure 2 Total biomass yield of wheat with various amendments applied in spring 2008, at Naicam, Saskatchewan (P-deficient soil – Experiment 1 established in spring 2008).

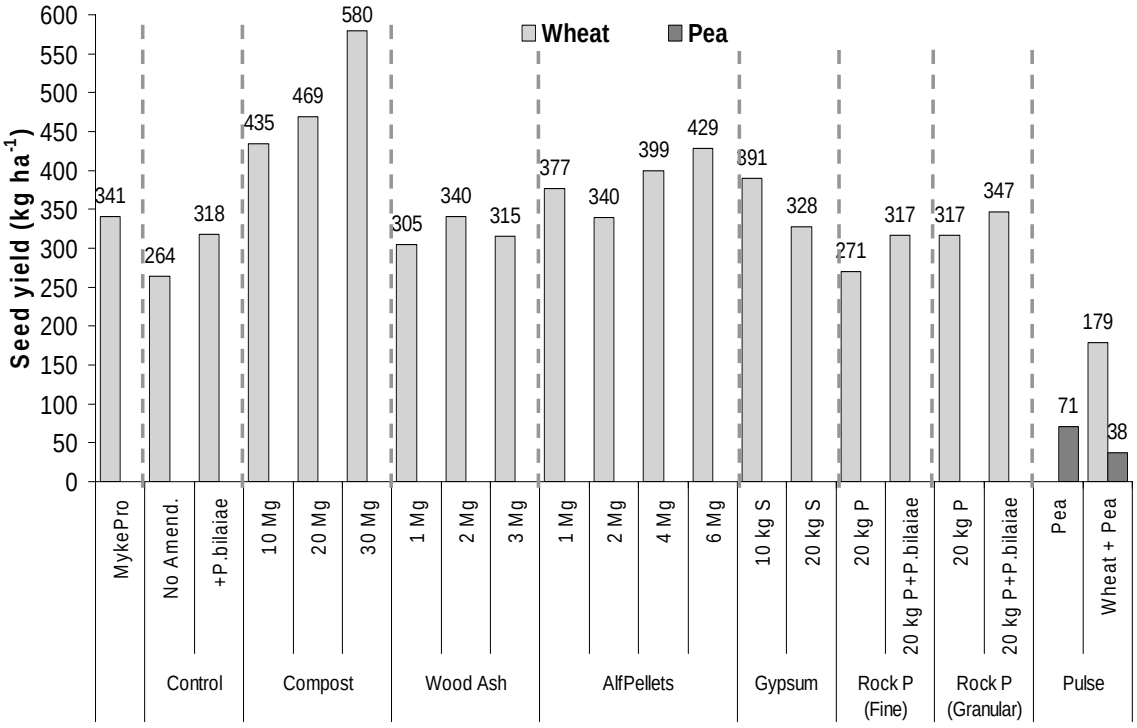

Figure 3 Seed yield of wheat in 2008 with various amendments applied in spring 2008 at Star City, Saskatchewan (S-deficient soil – Experiment 2 established in spring 2008).

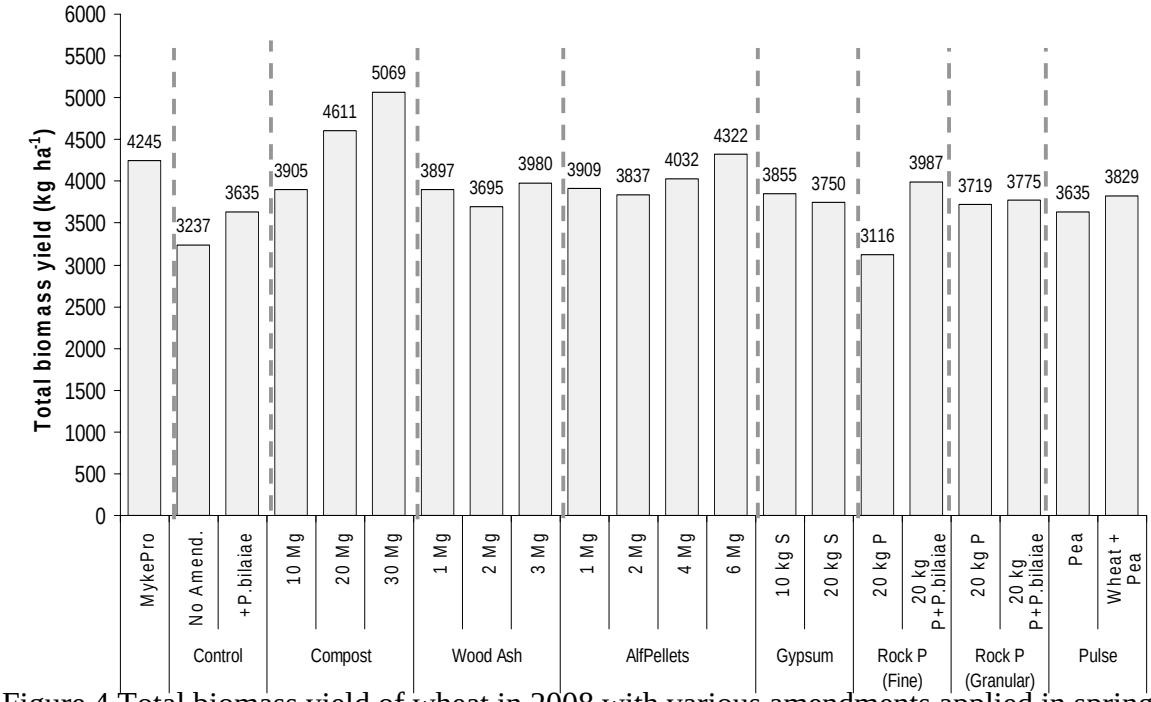

Figure 4 Total biomass yield of wheat in 2008 with various amendments applied in spring 2008 at Star City, Saskatchewan (S-deficient soil – Experiment 2 established in spring 2008).

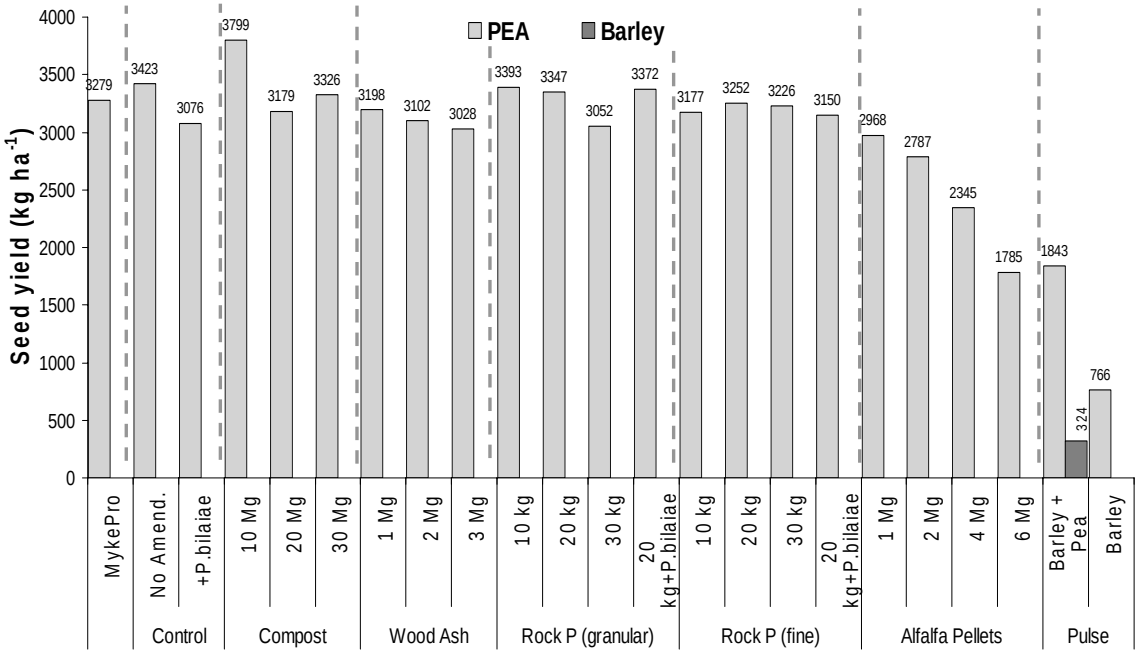

Figure 5 Seed yield of field pea with various amendments applied in spring 2009 at Naicam, Saskatchewan.

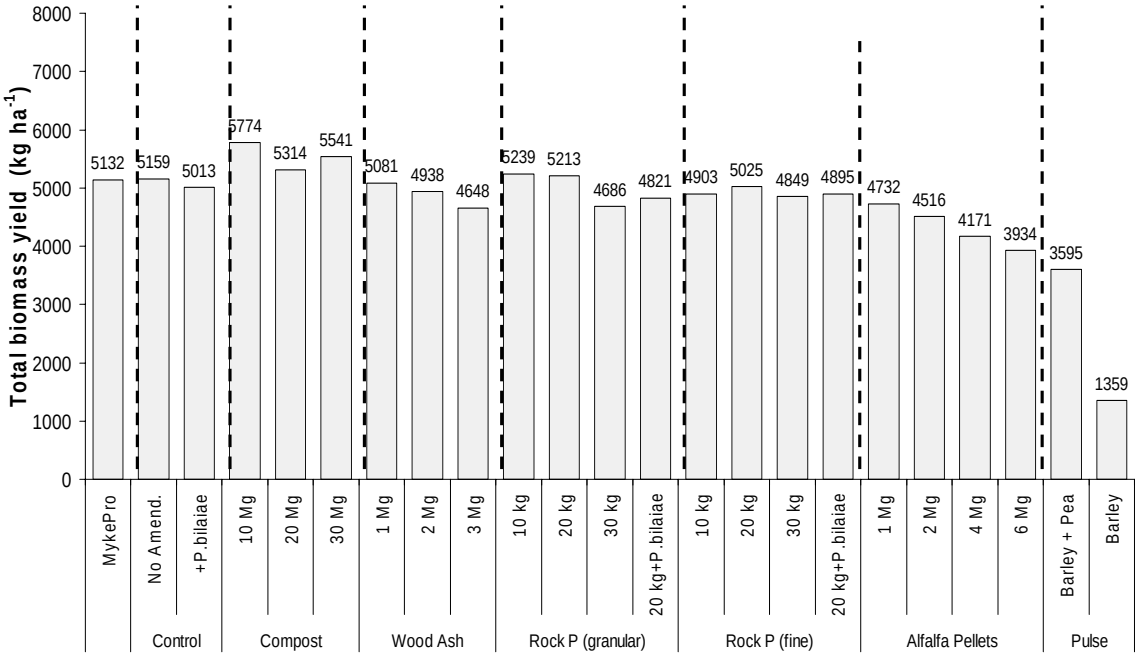

Figure 6 Total biomass yield of field pea with various amendments applied in spring 2009 at Naicam, Saskatchewan.

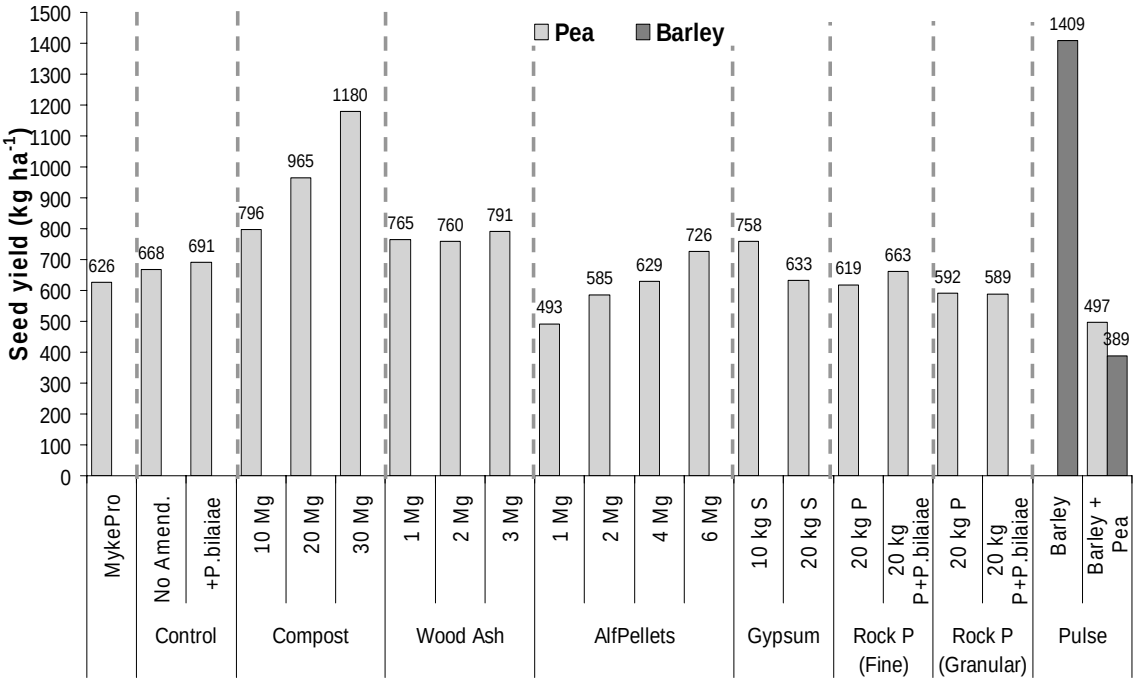

Figure 7 Seed yield of field pea in 2009 with various amendments applied in spring 2009 at Star City, Saskatchewan.

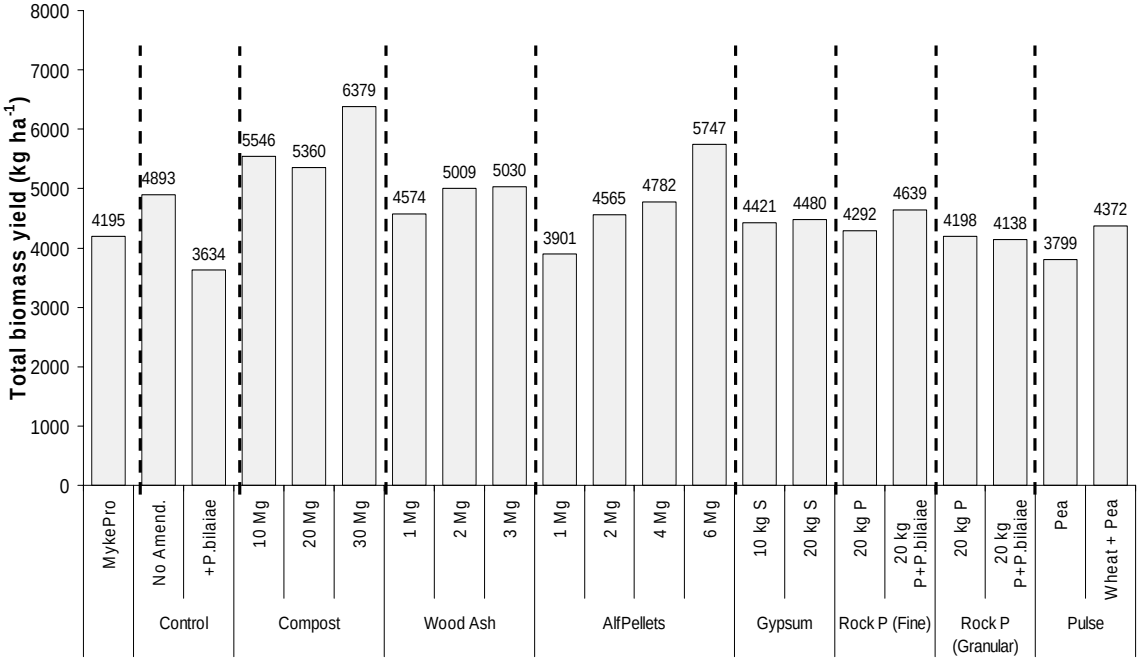

Figure 8 Total biomass yield of field pea in 2009 with various amendments applied in spring 2009 at Star City, Saskatchewan.

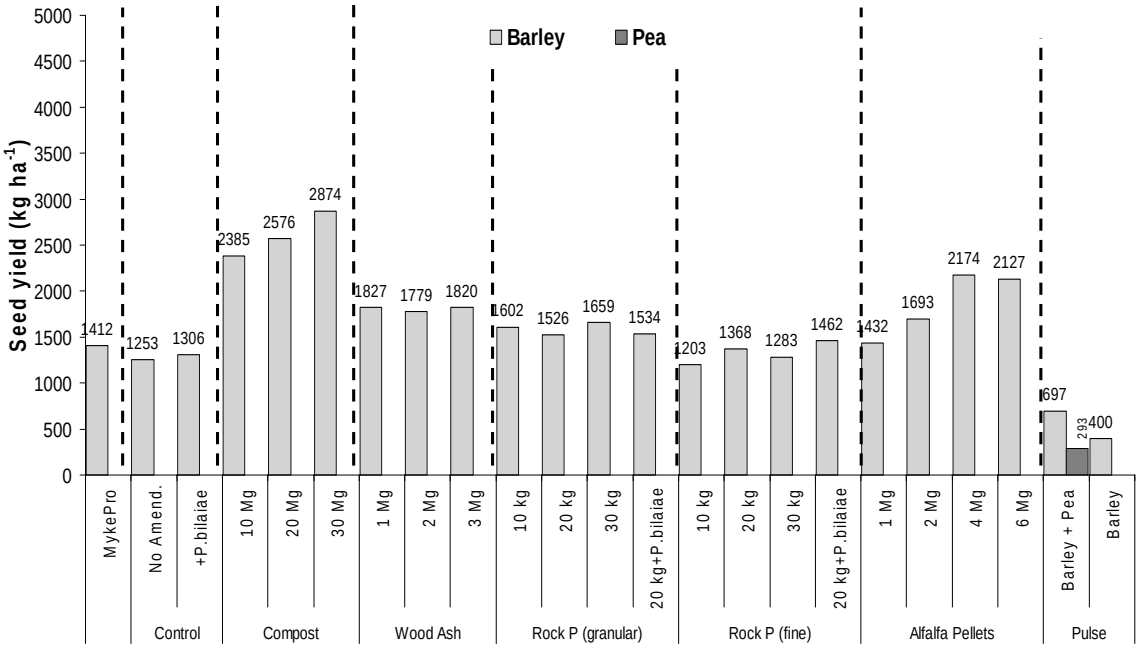

Figure 9 Seed yield of barley in 2010 with various amendments applied in spring 2010 at Naicam, Saskatchewan.

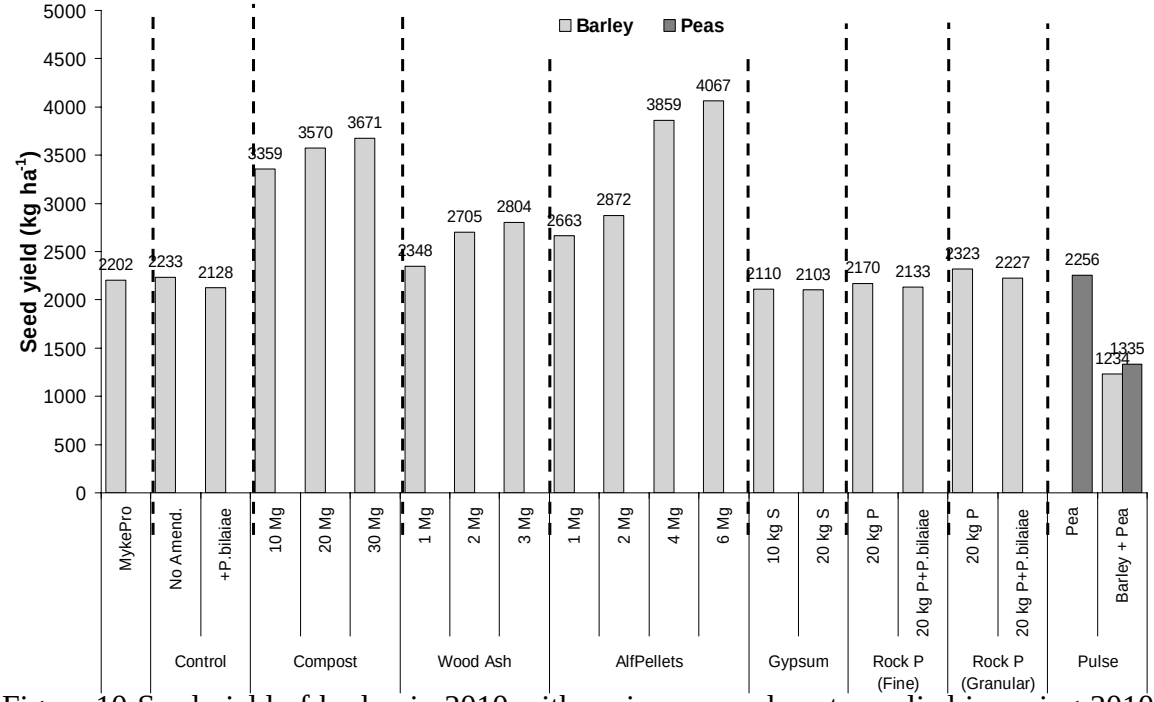

Figure 10 Seed yield of barley in 2010 with various amendments applied in spring 2010 at Star City, Saskatchewan.