Input Level and Crop Diversity Effects on Nitrate-N, Extractable P, Aggregation, and Organic C and N in Soil after Two 6-Year Crop Rotation Cycles

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Background

- Under and over fertilizer application is uneconomical, but any fertilizer N applied in excess of crop needs has the potential for environmental damage through nitrate leaching and denitrification (N_2O emissions).
- Changes in nutrient accumulation/distribution in soil profile and in soil properties vary with rates, sources and duration of fertilizer application, crop species, yield potential, rooting depth, volume and mass, soil type, climate, amount and placement of residues, etc.
- Crops with taproots can go deep into the soil, use nutrients present in the sub-soil and make them available at surface after residues are returned to soil. This can improve economic productivity under low fertility conditions in the surface soil.
- Under high fertility conditions, it improves the retention of nutrients, resulting benefits of sustainable crop production, economics, environment (soil/water/air) etc.
- In the soil depth profile, the concentration of nitrate-N can be elevated by legumes in a rotation, green manure and summer-fallow etc.
- Elimination of tillage, retaining crop residues, adequate fertilization, and diversified cropping systems including both annual and perennial forage crops can be used to increase organic matter and aggregation in soil.

Objective

To determine the influence of input level and crop diversity on distribution of nitrate-N and extractable P in the soil depth profile, aggregation, and organic C and N in soil after two 6-year rotation cycles under various alternative cropping systems.

Materials and Methods

- 3 input levels x 3 cropping diversities x 6-year crop rotations/sequences in 4 replications (216 plots).
- Soil in each plot was sampled in autumn 2006 from the 0-15, 15-30, 30-60 and 60-90 cm depths in all plots. Soil samples up to 240 cm depth in selected treatments.
- 0-7.5 and 7.5-15 cm soil for organic C and N.

- 0-5 cm soil for dry aggregation

Input Levels

Organic (ORG):

« Management based on non-chemical means to mimic what an organic grower might do.

Reduced (RED):

« Reduced tillage is used to reduce non-renewable inputs while chemicals are used to supplement management practices.

High (HIGH):

« Inputs based on pest thresholds and soil tests. Chemical inputs compliment conventional tillage practices.

Cropping Diversity

Low (LOW):

ORG: GM fallow-wheat-wheat-GM fallow-mustard-wheat

RED: Chem fallow-wheat-wheat-Chem fallow-canola-wheat

HIGH: Till fallow-wheat-wheat-Till fallow-canola-wheat

Diversified Annual Grains (DAG):

ORG: GM fallow-wheat-pea-barley-GM fallow-mustard

RED: Canola-fall rye-pea-barley-flax-wheat

HIGH: Canola-fall rye-pea-barley-flax-wheat

Diversified Annual and Perennial (DAP):

ORG : Mustard-wheat-barley-alfalfa-hay-hay

RED: Canola-wheat-barley-alfalfa-hay-hay

HIGH: Canola-wheat-barley-alfalfa-hay-hay

Summary and Conclusions

Nitrate-N (Figures 1, 2, 3, 4, 5 and 6)

- Nitrate-N in soil was higher at HIGH input under LOW diversity, ORG input under DAG diversity, with the lowest at all 3 input levels under DAP diversity.
- Some downward movement of nitrate-N in the soil profile under LOW and DAG diversity at HIGH input.

- In LOW cropping diversity, nitrate-N in soil was highest after GM/F1 at ORG input, GM/F2 at RED input and GM/F1 at HIGH input, and was lowest after wheat2 or wheat3 at ORG input, after canola at RED input, and wheat3 at HIGH input level.
- In DAG cropping diversity, nitrate-N in soil was highest after GM/F1 at ORG input, and after wheat at RED and HIGH inputs, and was lowest after barley at ORG input, after spring rye at RED input, and after canola at HIGH input.
- In DAP cropping diversity, nitrate-N in soil was highest after hay2 and was usually lowest after alfalfa at all input levels.
- In the 0-240 cm soil depth, total amount of nitrate-N was highest at HIGH input and LOW diversity and lowest at ORG input and DAP diversity combination.
- In soil layers below 90 cm depth, amount of nitrate-N (averaged across three inputs) was usually highest with LOW diversity and Lowest with DAP diversity, and nitrate-N, when averaged across three diversities, was higher at HIGH input than the other two inputs.

Extractable P (Figures 7 and 8)

- HIGH or RED input had more extractable P (but small increase) in the 0-15 (also 15-30) cm soil depth than ORG input level.
- There was no effect of crop diversity on extractable P in soil.
- Extractable P was low in the surface soil layers, and extremely low in the sub-soil layers. This indicates that at this site there may be a little potential for bringing P from sub-soil to the surface soil by using deep taproot crops.
- This also suggests that if surface and sub-soil are low in available P or other nutrients, it may not be possible to sustain high crop yields under organic farming systems without using external nutrient sources.

Soil Aggregation (Figures 9, 10 and 11)

- Proportion of fine aggregates (< 1.3 mm – erodible soil fraction) was higher with LOW diversity and HIGH input, and lowest with DAG diversity and RED input. The converse was true for large aggregates (> 12.7 mm).

Soil Organic C and N (Figures 12, 13, 14, 15 and 16)

- LFOM, LFOC and LFON were higher at RED input than ORG and HIGH inputs, and also higher under DAG and DAP diversity than LOW diversity.
- The findings suggest that soil quality can be improved and nutrient accumulation in the soil profile can be minimized by reducing or eliminating tillage and proper fertilizer input under diversified cropping systems.

Acknowledgements

We thank Don Gerein and other staff for technical assistance, and Erin Cadieu for printing the poster.

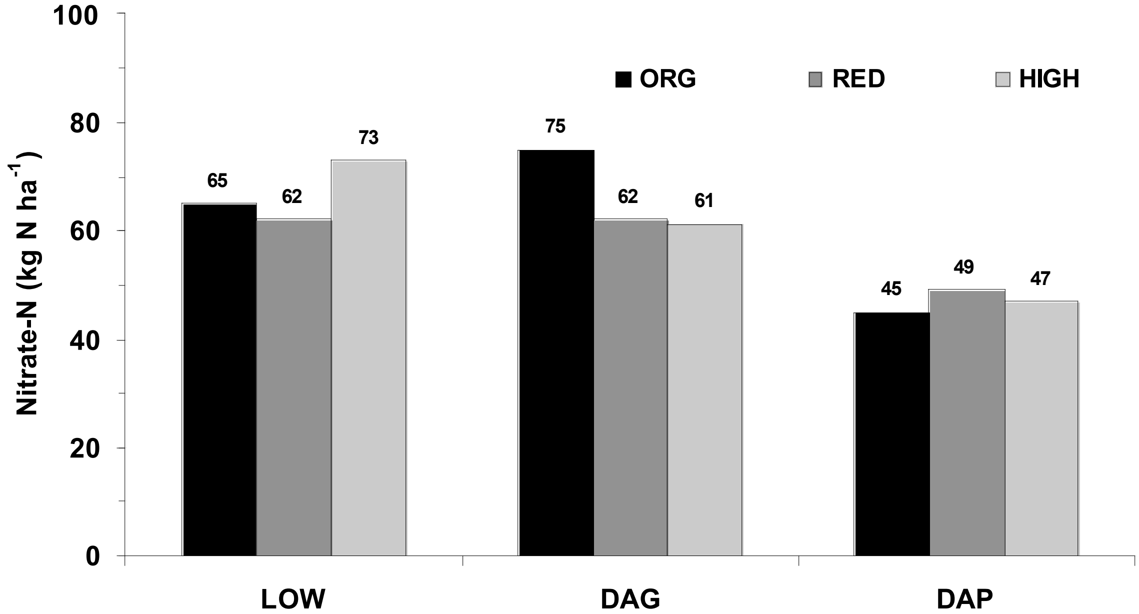

Figure 1. Influence of input level on nitrate-N in 0-90 cm soil under three cropping diversities in 2006 at Scott, Saskatchewan.

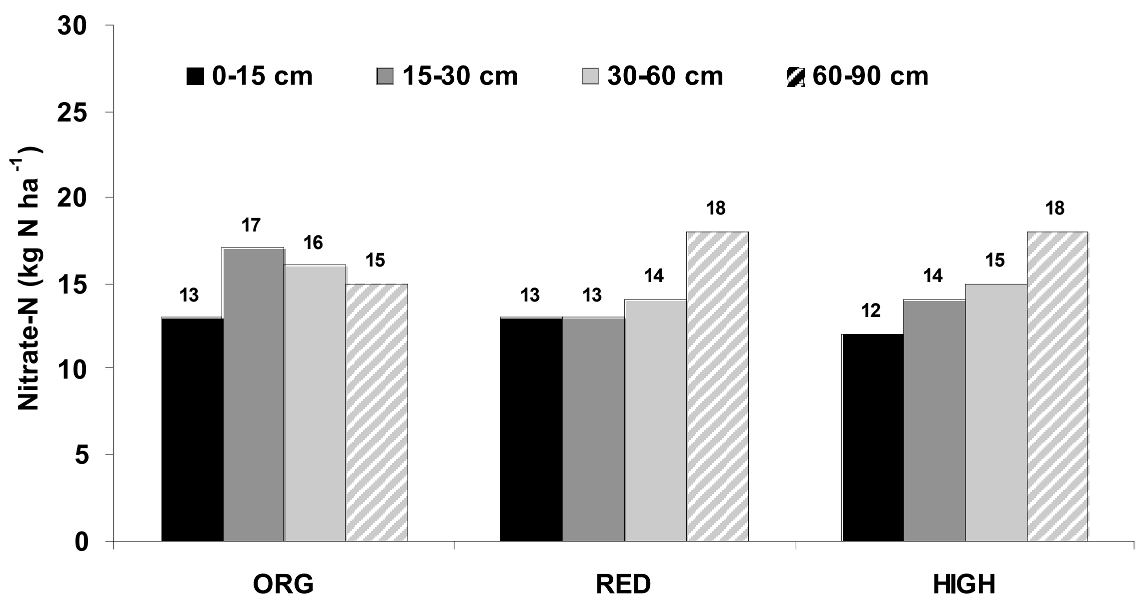

Figure 2. Distribution of nitrate-N in the soil profile (0 to 90 cm) in relation to input levels in 2006 at Scott, Saskatchewan.

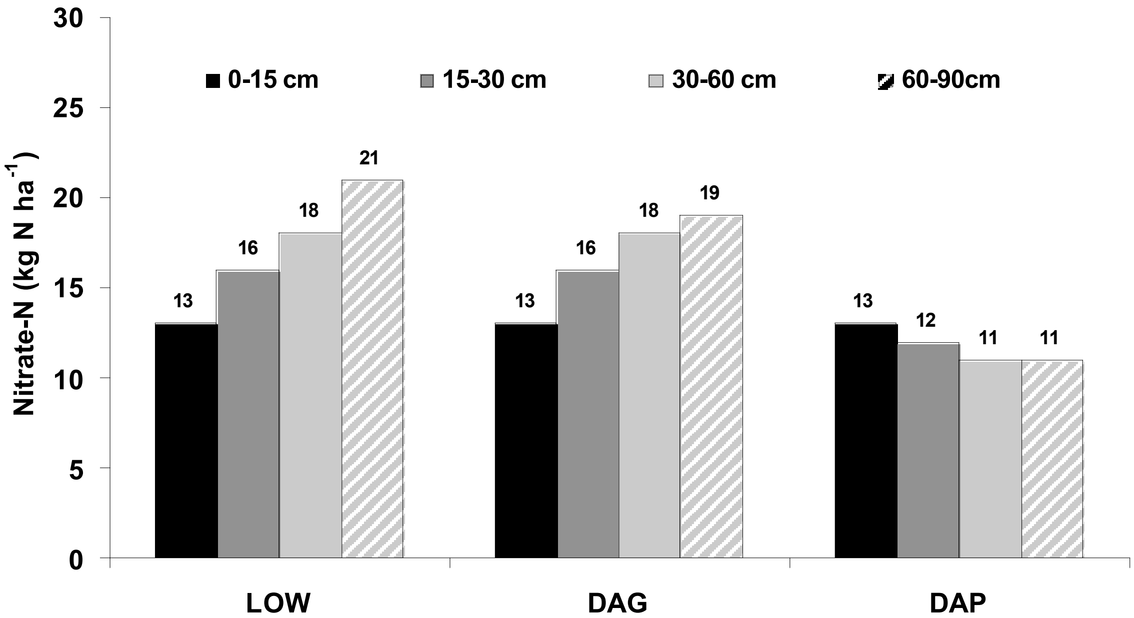

Figure 3. Distribution of nitrate-N in the soil profile (0 to 90 cm) in relation to cropping diversity in 2006 at Scott, Saskatchewan.

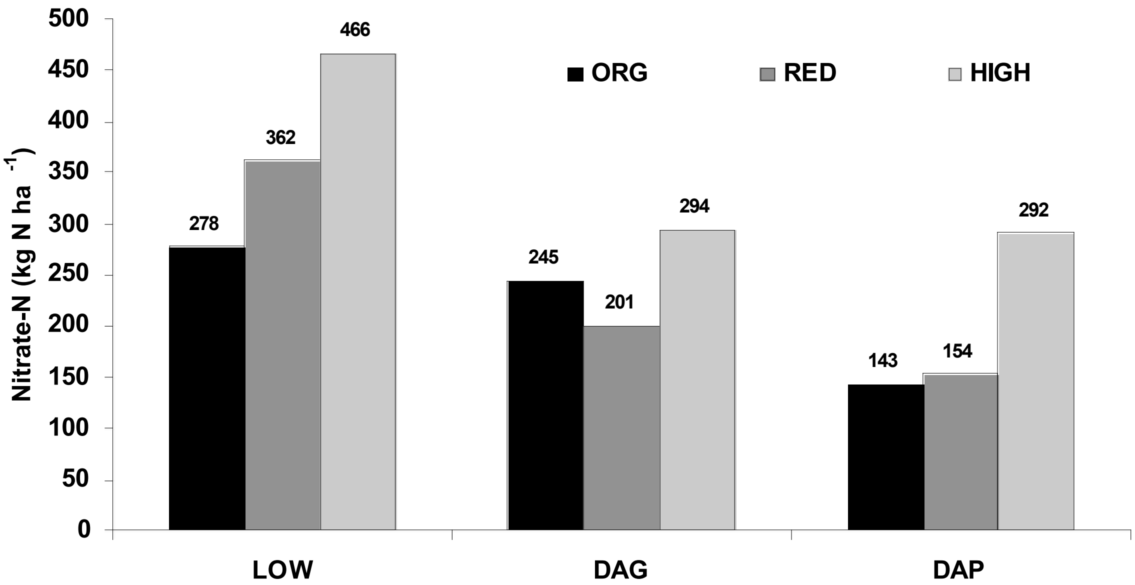

Figure 4. Influence of input level on nitrate-N in 0-240 cm soil under three cropping diversities in selected treatments (first wheat phase) in 2006 at Scott, Saskatchewan.

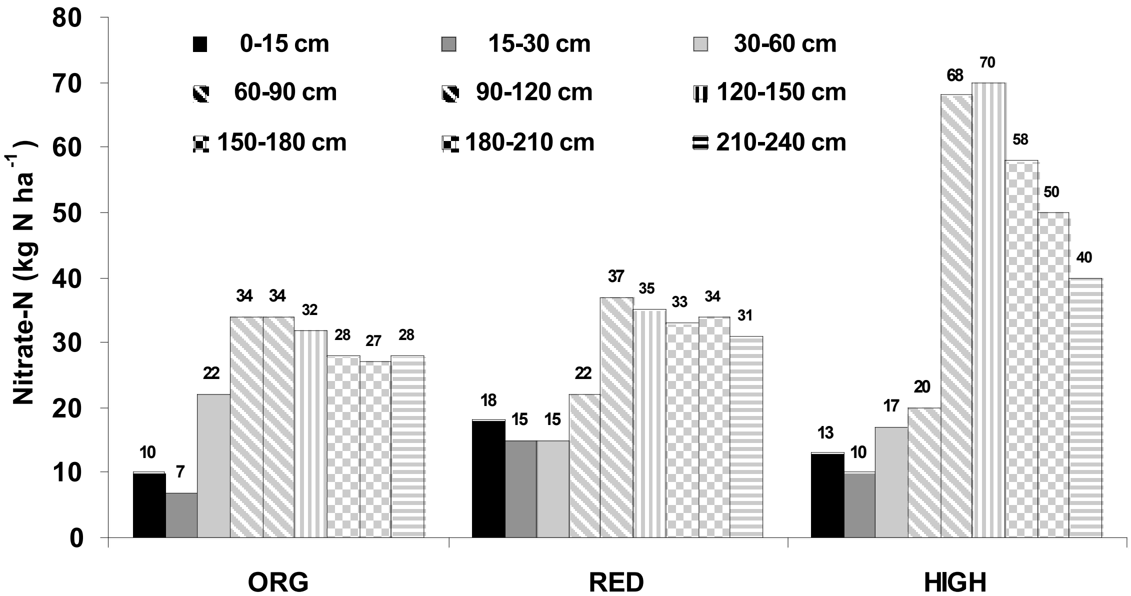

Figure 5. Distribution of nitrate-N in the soil profile (0 to 240 cm) in relation to input levels in selected treatments (first wheat phase) in 2006 at Scott, Saskatchewan.

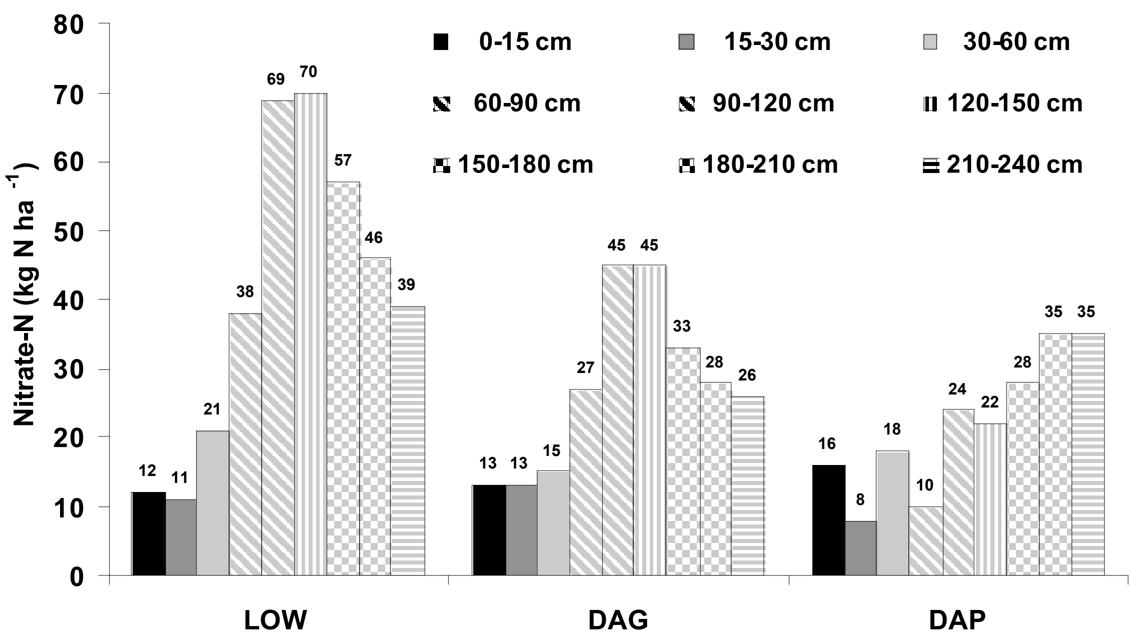

Figure 6. Distribution of nitrate-N in the soil profile (0 to 240 cm) in relation to cropping diversity in selected treatments (first wheat phase) in 2006 at Scott, Saskatchewan.

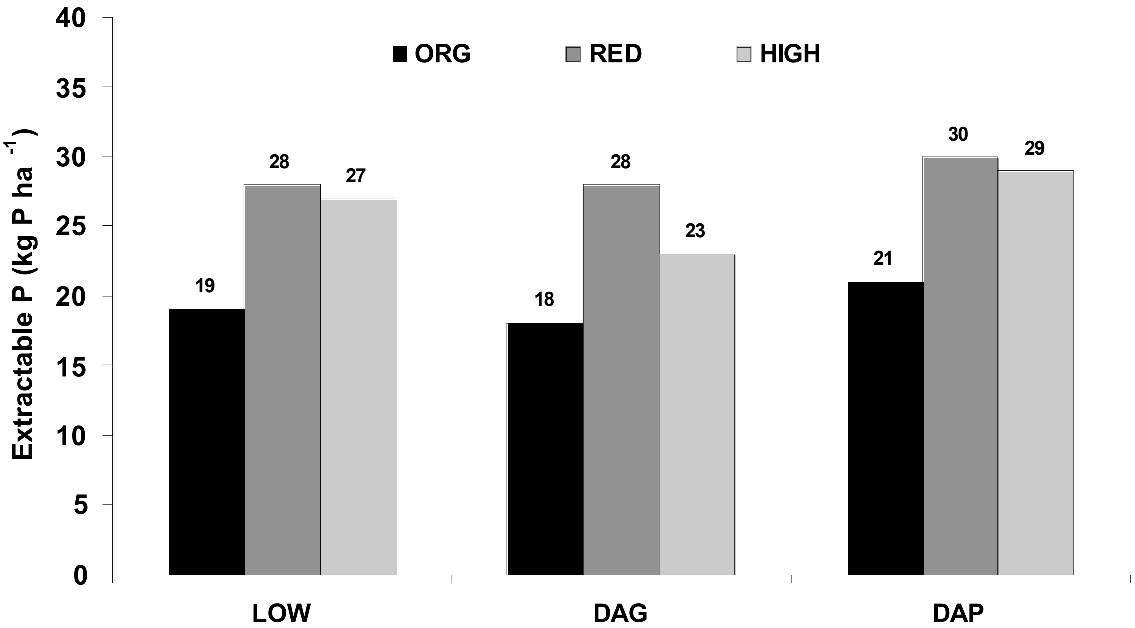

Figure 7. Influence of input level on extractable P in 0-90 cm soil under three cropping diversities in 2006 at Scott, Saskatchewan.

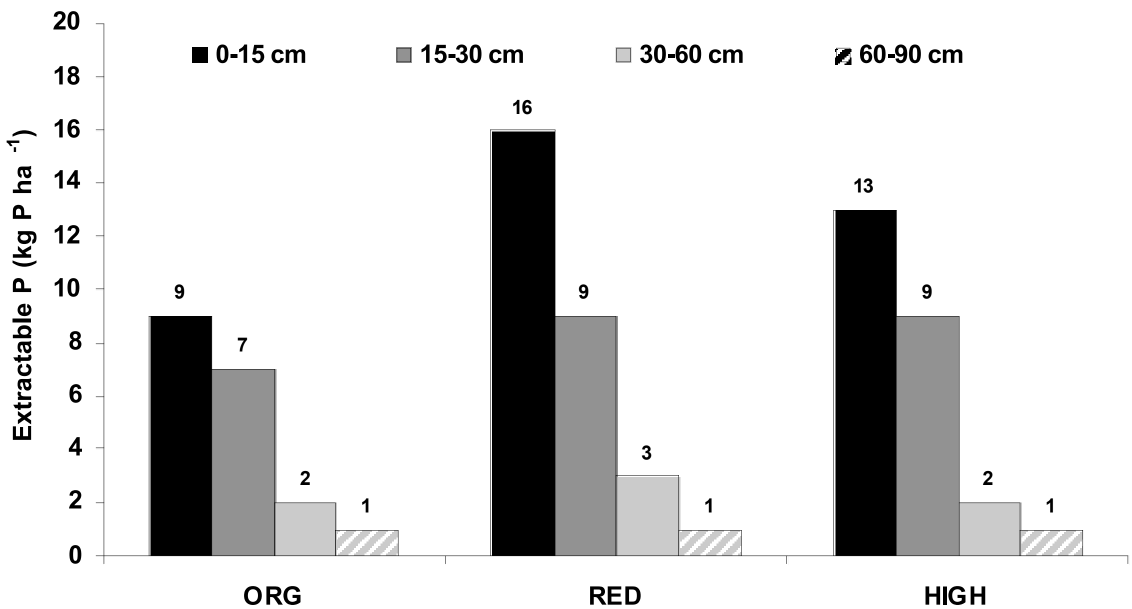

Figure 8. Distribution of extractable P in soil profile (0 to 90 cm) in relation to input levels in 2006 at Scott, Saskatchewan.

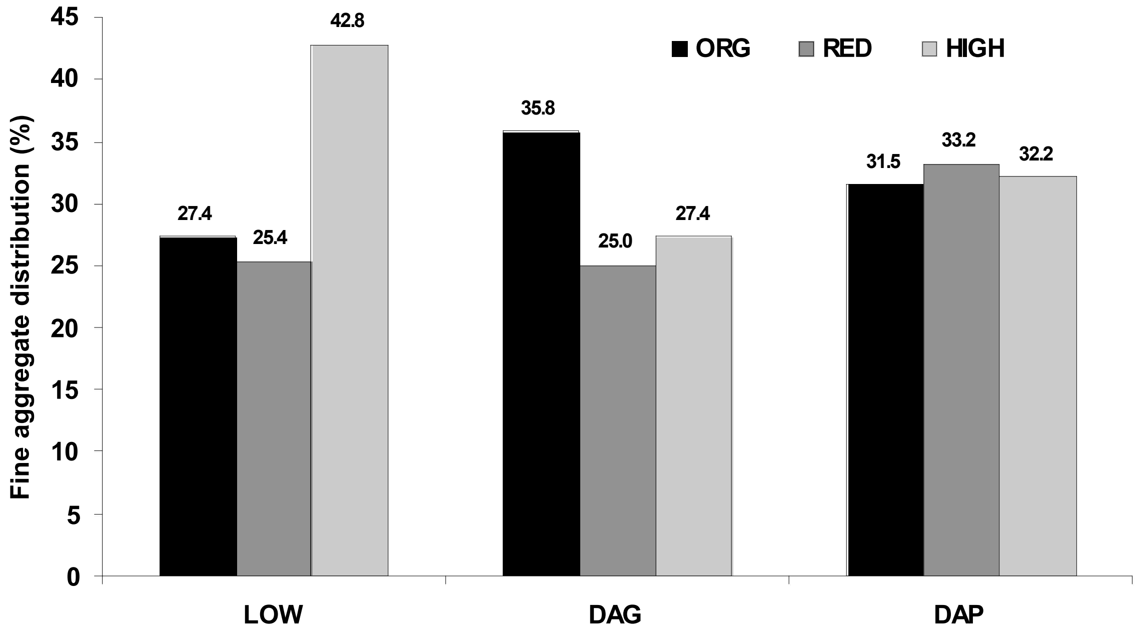

Figure 9. Proportion (%) of fine (< 1.3 mm) aggregates in 0-5 cm soil depth in autumn 2006 for input level x crop diversity interaction under various alternative cropping systems at Scott, Saskatchewan.

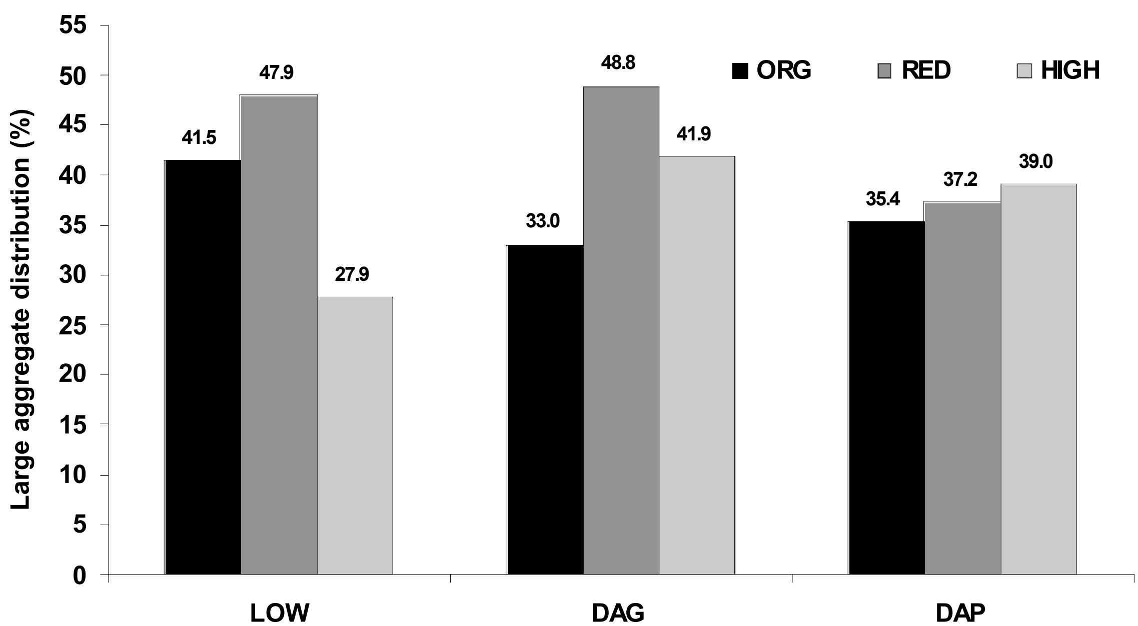

Figure 10. Proportion (%) of large (> 12.7 mm) aggregates in 0-5 cm soil depth in autumn 2006 for input level x crop diversity interaction under various alternative cropping systems at Scott, Saskatchewan.

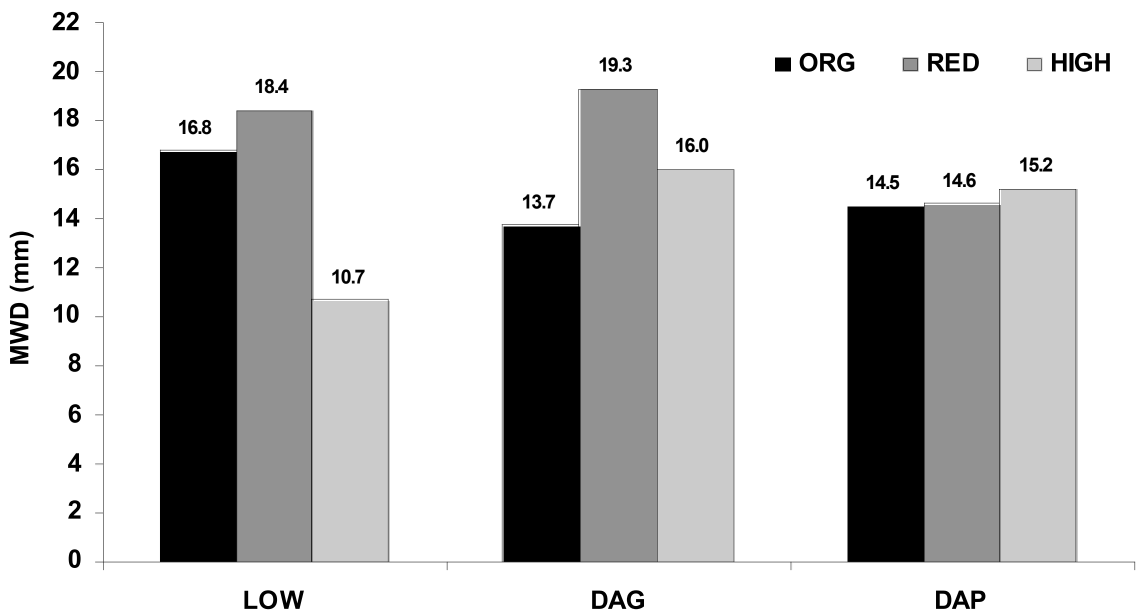

Figure 11. Mean weight diameter (MWD) of aggregates in 0-5 cm soil depth in autumn 2006 for input level x crop diversity interaction under various alternative cropping systems at Scott, Saskatchewan.

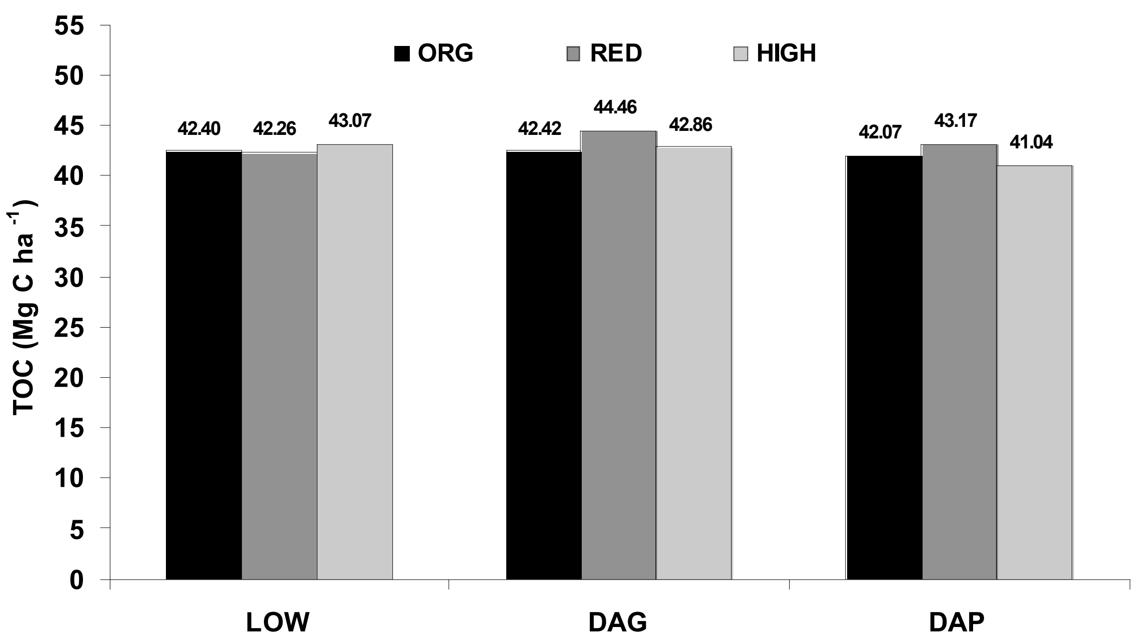

Figure 12. Total soil organic C (TOC) in 0-15 cm soil depth in autumn 2006 for three input levels and three crop diversities under various alternative cropping systems at Scott, Saskatchewan.

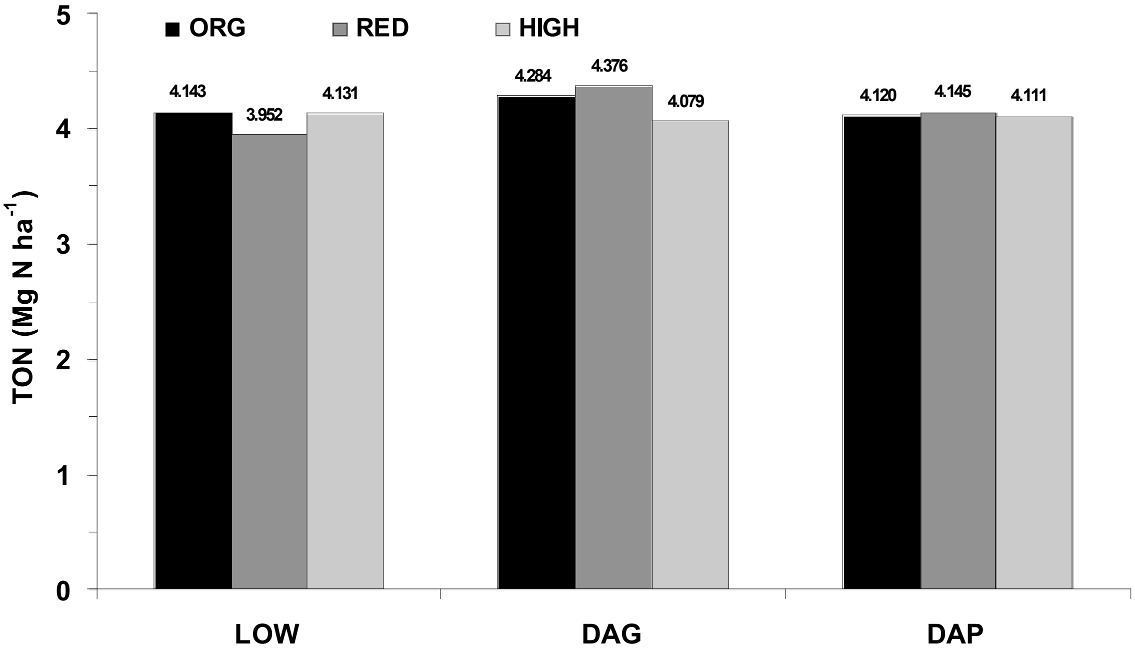

Figure 13. Total soil organic N (TON) in 0-15 cm soil depth in autumn 2006 for three input levels and three crop diversities under various alternative cropping systems at Scott, Saskatchewan.

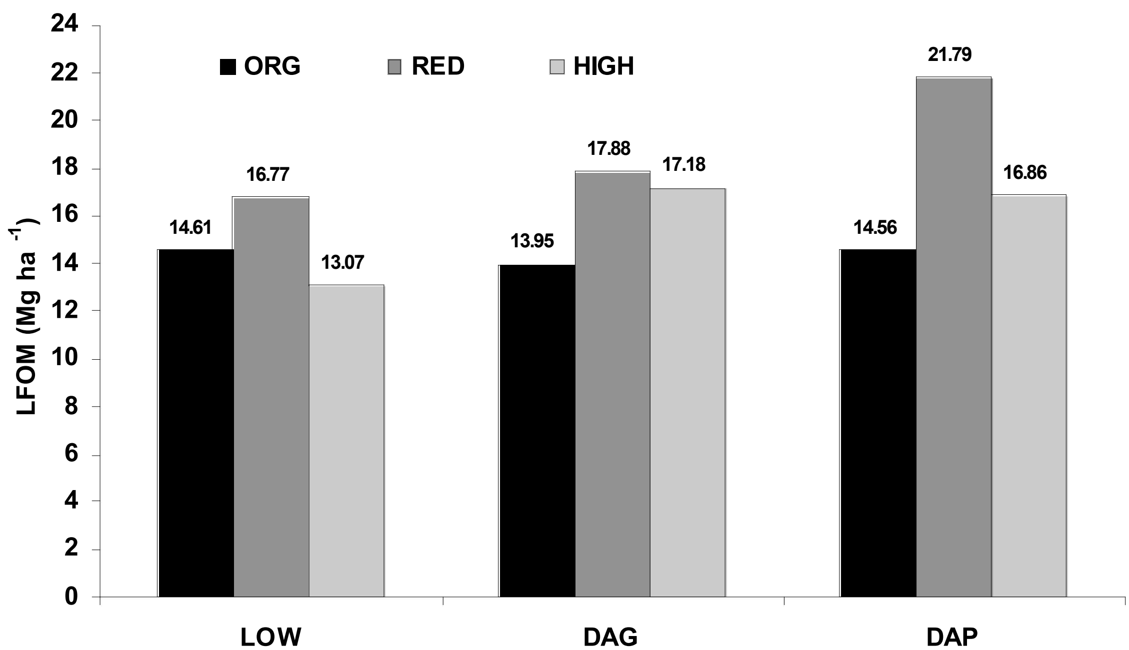

Figure 14. Light fraction organic matter (LFOM) in 0-15 cm soil depth in autumn 2006 for three input levels and three crop diversities under various alternative cropping systems at Scott, Saskatchewan.

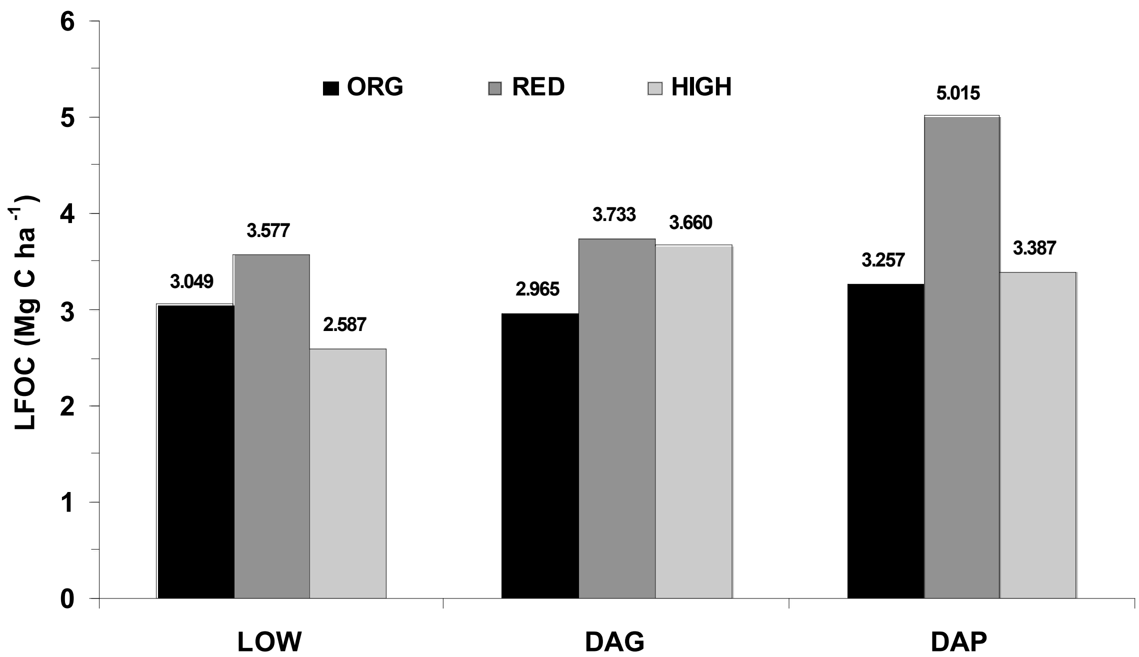

Figure 15. Light fraction organic C (LFOC) in 0-15 cm soil depth in autumn 2006 for three input levels and three crop diversities under various alternative cropping systems at Scott, Saskatchewan.

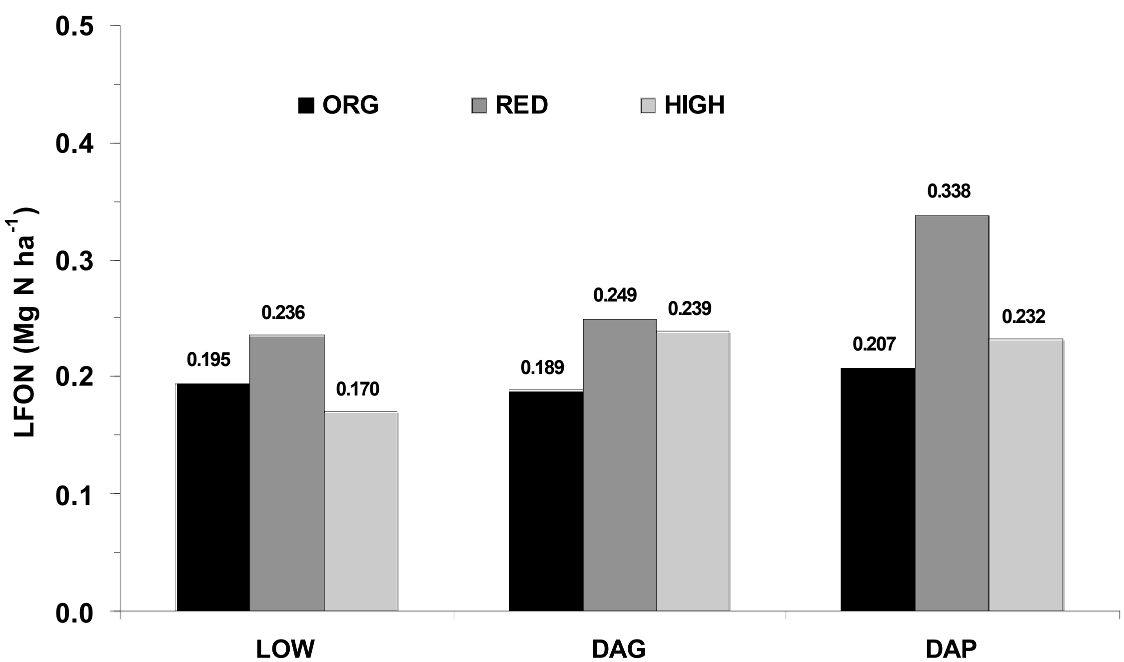

Figure 16. Light fraction organic N (LFON) in 0-15 cm soil depth in autumn 2006 for three input levels and three crop diversities under various alternative cropping systems at Scott, Saskatchewan.