# Feasibility of Polymer-Coated Urea (ESN) for Agronomic and Environmental Considerations in the Parkland Region of Saskatchewan (September 9, 2013)

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**Background:**

- Inefficient use of N fertilizer may contribute to environmental degradation, as portion of the applied N not used by the crop is presumed to be lost to the environment through runoff, leaching and gaseous emissions.
- Additionally, low use efficiency of nutrients applied as fertilizers results in lower economic returns to producers from their investment in fertilizer inputs.
- In the Canadian Prairies, most soils are deficient in plant-available N. Thus, application of N fertilizer is essential for optimum crop yield.
- Fertilizer N when applied to increase crop production can be a source of nitrous oxide ($N_2O$) emission to the atmosphere and nitrate in surface runoff and ground water, if the supply of available N is not synchronized with crop uptake.
- The N use efficiency (NUE) from applied fertilizers is usually less than 50% in the year of application. Thus, suggesting that the improvements in NUE are critical to increase economic returns of crop production and minimize environmental damage from the leakage of N from soil to water and air.
- The N fertilizers are more efficient, if N supply is synchronized with crop N demand. Polymer-coated urea is designed to synchronize its N release pattern with crop N uptake, because polymers used for coating the urea granules are usually durable and exhibit predictable nutrient release rates under average temperature and moisture conditions.
- Polymer-coated urea can improve NUE by increasing N uptake and reducing accumulation of residual nitrate-N in soil, thus lowering the potential of N leakage to water and air. Increased NUE may also increase crop yield and produce quality, thus providing an economic benefit to producers.

- Canola and wheat are major cash crops in the Parkland region of Saskatchewan, and urea is the most commonly used dry N fertilizer because it is cost effective compared to other dry N fertilizers.
- One pass seeding and fertilizer application (i.e., direct seeding, no-tillage, or zero-tillage) is becoming very popular in this area, because it reduces time, cost and equipment needs for seeding, tillage intensity, and loss of soil and water, but it needs relatively larger, complex and expensive seeding equipment for placement of seed and fertilizer in separate bands.
- Seedrow-placement of urea is a popular option for producers, as it allows seeding and fertilizer application in single operation, and also reduces labour, fuel, equipment, draft and time requirements, and soil disturbance.
- Band placement in subsoil also reduces volatilization losses of N from urea and improves fertilizer use efficiency. However, the proximity of urea to seed when applied in the same band/row can result in seedling damage at N rates adequate for optimum crop yield.
- To avoid extra cost on seeding equipment, many producers tend to place the fertilizer in the seedrow band, which has the potential to reduce seedling emergence (also called seedling density, stand density, or plant density) and yield.
- This report summarizes the results of field experiments conducted in the Parkland region of Saskatchewan to compare the effects of non-coated commercial urea (called urea) and polymer-coated urea (called ESN) on seedling emergence, seed yield, protein concentration (PC) in seed and N uptake of oilseeds and cereals, using different combinations of seed/fertilizer placements and timing of application.

**Summary of Findings**

**Fall and Spring Applied N (Tables 1 and 2)**

- A 3-year field (2004-2006) experiment was conducted at Star City, Saskatchewan, Canada, to determine the influence of polymer-coated urea (called ESN) versus conventional urea applied in fall and spring using different placement methods under conventional and zero tillage on seed yield of wheat, canola or barley and nitrous oxide ($N_2O$) gas emissions.

- There was a substantial increase in seed yield with applied N, and yield responses were usually similar for both tillage systems.
- Fall-banded urea was less effective in increasing seed yield than spring-side-banded urea in some cases when soil conditions were wet. Fall-banded ESN produced higher seed yield than similarly applied uncoated urea.
- For spring side-banded N, ESN had higher seed yield than uncoated urea. Split application (i.e., a half of N at seeding and the other half at tillering) and spring 50:50 blend application of ESN and uncoated urea produced higher seed yield than uncoated urea in some years.
- The lower seed yield with urea is believed to be due to higher gaseous N loss (through denitrification) and/or nitrate leaching compared with ESN.
- Economic analysis indicated that application of urea produced net revenue similar to or greater than ESN, split urea applications, or a blend of ESN and urea. In some limited situations where ESN, split urea applications, or a blend of ESN and urea produced greater crop yield than urea, the increased yield was not sufficient to cover the extra cost of ESN or the split application.
- The $N_2O$ emissions were higher for fall-applied N than spring-applied N, when soil conditions favored denitrification, thus suggesting that fall application of urea N may not be a suitable management option under wet soil conditions. Application of ESN tended to reduce $N_2O$ emissions compared to uncoated urea in some years/under some environmental conditions, but the improved crop production and environmental benefits have to compensate for the extra premium in fertilizer cost of ESN compared to urea.

**Seedrow-Placed Urea N (Tables 3 to 6)**

- Two 3-year (2007 to 2009) field experiments were conducted on canola and wheat at Melfort Research Farm, Saskatchewan, Canada, to determine the influence of different combinations of three N rates (40, 80 and 120 kg N $ha^{-1}$), two urea coatings [non-coated urea (urea) and urea coated with polymer (ESN)] and two methods of placement (side-banded N and seedrow-placed N, with knives), plus a zero-N control, on seedling emergence and seed yield.

- Side-banded N did not show any detrimental effect on seedling emergence for both crops compared to zero-N control.
- Seedling emergence was lower with seedrow-placed N compared to side-banded N for urea, especially for canola.
- Seedling emergence decreased with increasing N rate for urea with seedrow-placed N, and the differences in seedling emergence between seedrow-placed N and side-banded N increased with increasing N rate.
- There was usually little or no detrimental effect of seedrow-placed N for ESN on seedling emergence.
- Seed yield was generally greater with ESN than urea, when the N fertilizers were seedrow-placed at high N rates, suggesting the effectiveness of ESN in providing greater N application options for producers.

**Conclusions**

- The findings suggest that ESN can be a suitable/effective management tool in enhancing seed yield for fall-applied N when wetter soil moisture conditions exist and for safely increasing rates of fertilizer N that can be placed with seed, while also minimizing potential for gaseous N losses over the winter and in early spring.
- The main consideration for farmers will be the higher cost of ESN relative to urea. The cost factor can be reduced by using a blended mixture of ESN and urea, but the cost of second application for split application of urea has to be reckoned with the potential benefits, which are management of risk associated with mid-summer drought and potentially higher seed protein content.
- Factors, such as soil texture, soil moisture and drying, crop type, row spacing, opener type and depth of seeding can influence the rate of N that can be safely placed in the seedrow. Therefore, in order to save money and get the maximum yield and economic benefit from ESN (after considering the extra cost of ESN and cash value of the crop), it is suggested that farmers should/must apply and compare ESN with urea in marked test strips, and obtain yields to make assessment on their own individual farm situations, and then consider fertilization of whole/full fields/farms on a regular basis.

Table 1. Seed yield and net revenue of wheat, canola and barley as affected by N rate, source, time and mode of application at Star City, Saskatchewan in 2004, 2005 and 2006

| Treatment (N source/rate)[y] | Seed yield (kg ha$^{-1}$) | | | Net revenue ($ ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | 2004 (wheat) | 2005 (canola) | 2006 (barley) | 2004 (wheat) | 2005 (canola) | 2006 (barley) |
| 1. Control (zero-N) | 2395 | 1426 | 3294 | 102 | 212 | 143 |
| 2. Urea SB at 30 kg N ha$^{-1}$ | 3268 | 2066 | 4618 | 258 | 451 | 332 |
| 3. Urea SB at 60 kg N ha$^{-1}$ | 4420 | 2316 | 5256 | 438 | 529 | 405 |
| 4. Urea SB at 90 kg N ha$^{-1}$ | 4674 | 2715 | 5683 | 510 | 678 | 441 |
| 5. ESN SB at 30 kg N ha$^{-1}$ | 3271 | 1920 | 4565 | 201 | 372 | 313 |
| 6. ESN SB at 60 kg N ha$^{-1}$ | 4114 | 2549 | 5415 | 354 | 618 | 413 |
| 9. Split at 60 kg N ha$^{-1}$ | 3863 | 2533 | 5374 | 326 | 624 | 419 |
| 7. Urea FB[z] at 60 kg N ha$^{-1}$ | | 2019 | 4517 | | 354 | 240 |
| 8. ESN FB[z] at 60 kg N ha$^{-1}$ | | 2202 | 5002 | | 419 | 304 |
| 10. Blend at 60 kg N ha$^{-1}$ | 3960 | 2456 | 5337 | 326 | 585 | 409 |

[z]No fall application was applied in 2004.
[y]SB = Spring banded; ESN = Polymer-coated urea (called ESN); FB = Fall banded.

Table 2. Growing season (GS) and total $N_2O$ loss as affected by tillage, time of application and form of urea fertilizer at Star City, Saskatchewan, in 2005 and 2006[a]. The N loss is expressed on a land area basis (g N $ha^{-1}$) and per unit of N uptake

| | | GS and total $N_2O$-N loss | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2005 | | | | 2006 | | | |
| Fertilizer treatment[b] | Tillage | GS[a] | Total | GS | Total | GS | Total | GS | Total |
| | | – g N $ha^{-1}$ – | | – g N (kg $N^{-1}$) – | | – g N $ha^{-1}$ – | | – g N (kg $N^{-1}$) – | |
| 1 control (zero-N) | NT | 321 | 697 | 9.3 | 20.2 | 937 | 1136 | 24.9 | 30.2 |
| 2 Urea SB | NT | 500 | 787 | 8.9 | 14.0 | 1370 | 1600 | 14.7 | 17.2 |
| 3 ESN SB | NT | 676 | 936 | 9.9 | 13.7 | 1090 | 1269 | 14.3 | 16.7 |
| 4 Urea FB | NT | 616 | 970 | 15.8 | 24.9 | 922 | 1726 | 15.7 | 29.4 |
| 5 ESN FB | NT | 461 | 590 | 9.3 | 12.0 | 683 | 1128 | 9.6 | 15.8 |
| 6 Urea SB | CT | 1220 | 1416 | 24.6 | 28.6 | 1310 | 1587 | 17.8 | 21.6 |
| 7 ESN SB | CT | 679 | 854 | 10.8 | 13.5 | 837 | 1193 | 9.8 | 14.1 |
| 8 Urea FB | CT | 708 | 917 | 15.9 | 20.6 | 1050 | 2227 | 18.2 | 38.9 |

[a]In 2005 total loss includes those from after harvest till October 25 (i.e., fall period); in 2006 total loss includes those from before seeding.
[b]SB and FB refer to spring-banded and fall-banded application, respectively, and ESN refers to polymer-coated urea (called ESN).

Table 3. Seedling emergence of canola with urea and polymer-coated urea (ESN) fertilizers applied at different rates using knives at Melfort, Saskatchewan

| Treatment | | | Seedling emergence (plants $m^{-2}$) | | |
|---|---|---|---|---|---|
| N source | Placement method | N rate (kg N $ha^{-1}$) | 2007 | 2008 | 2009 |
| Urea | Side-banded | 40 | 137 | 151 | 163 |
| | | 80 | 111 | 132 | 180 |
| | | 120 | 128 | 127 | 199 |
| | Seedrow-placed | 40 | 100 | 96 | 146 |
| | | 80 | 79 | 44 | 89 |
| | | 120 | 58 | 32 | 45 |
| ESN | Side-banded | 40 | 119 | 146 | 148 |
| | | 80 | 102 | 136 | 207 |
| | | 120 | 115 | 151 | 196 |
| | Seedrow-placed | 40 | 130 | 128 | 197 |
| | | 80 | 140 | 122 | 199 |
| | | 120 | 133 | 115 | 211 |

Table 4. Seed yield of canola with urea and polymer-coated urea (ESN) fertilizers applied at different rates using knives at Melfort, Saskatchewan

| Treatment | | | Seed yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|
| N source | Placement method | N rate (kg N $ha^{-1}$) | 2007 | 2008 | 2009 |
| Urea | Side-banded | 40 | 1856 | 2126 | 1810 |
| | | 80 | 2081 | 2536 | 2347 |
| | | 120 | 2379 | 2723 | 2656 |
| | Seedrow-placed | 40 | 1670 | 2073 | 1710 |
| | | 80 | 1951 | 2416 | 1620 |
| | | 120 | 2176 | 2513 | 1197 |
| ESN | Side-banded | 40 | 2007 | 2172 | 1758 |
| | | 80 | 2130 | 2434 | 2225 |
| | | 120 | 2283 | 2782 | 2348 |
| | Seedrow-placed | 40 | 1502 | 2194 | 1781 |
| | | 80 | 2198 | 2722 | 2307 |
| | | 120 | 2265 | 2828 | 2461 |

Table 5. Seedling emergence of wheat with urea and polymer-coated urea (ESN) fertilizers applied at different rates using knives at Melfort, Saskatchewan

| Treatment | | | Seedling emergence (plants $m^{-2}$) | | |
|---|---|---|---|---|---|
| N source | Placement method | N rate (kg N $ha^{-1}$) | 2007 | 2008 | 2009 |
| Urea | Side-banded | 40 | 273 | 335 | 289 |
| | | 80 | 252 | 314 | 369 |
| | | 120 | 239 | 269 | 363 |
| | Seedrow-placed | 40 | 292 | 274 | 346 |
| | | 80 | 237 | 233 | 265 |
| | | 120 | 227 | 175 | 207 |
| ESN | Side-banded | 40 | 264 | 326 | 312 |
| | | 80 | 258 | 310 | 374 |
| | | 120 | 261 | 302 | 329 |
| | Seedrow-placed | 40 | 287 | 321 | 365 |
| | | 80 | 314 | 334 | 344 |
| | | 120 | 312 | 280 | 367 |

Table 6. Seed yield of wheat with urea and polymer-coated urea (ESN) fertilizers applied at different rates using knives at Melfort, Saskatchewan

| Treatment | | | Seed yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|
| N source | Placement method | N rate (kg N $ha^{-1}$) | 2007 | 2008 | 2009 |
| Urea | Side-banded | 40 | 2440 | 2785 | 2252 |
| | | 80 | 3068 | 3519 | 3188 |
| | | 120 | 2984 | 4001 | 3278 |
| | Seedrow-placed | 40 | 2376 | 2918 | 2308 |
| | | 80 | 2756 | 3508 | 2579 |
| | | 120 | 2376 | 3367 | 1822 |
| ESN | Side-banded | 40 | 2454 | 2907 | 2214 |
| | | 80 | 2950 | 3476 | 3085 |
| | | 120 | 2885 | 3488 | 3307 |
| | Seedrow-placed | 40 | 2488 | 2622 | 2298 |
| | | 80 | 2939 | 3745 | 3217 |
| | | 120 | 3094 | 3969 | 3588 |