Enhanced Efficiency Fertilizers in Maintaining Yield and Reducing Nitrogen Losses in Irrigated, Late-Sown Potatoes

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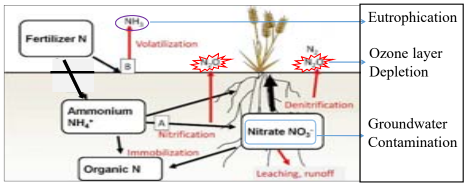
Introduction and Background

- Potato (*Solanum tuberosum*) is a very high nitrogen (N) demand crop. Irrigated potatoes cultivated in sandy soils have very low (<40 %) N use efficiency (NUE) because of shallow root system.
- Fertilizer N applied are easily lost through ammonia (NH_3) volatilization, nitrate (NO_3^-), and denitrification/ nitrous oxide (N_2O) emission and causes environmental hazards.
- Split application needs more labor and energy cost.



Enhanced Efficiency Fertilizers (EEFs)

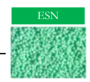
(1)Urease inhibition: Urea —Urease / NBPT→ Ammonia

(2)Nitrification inhibition: Ammonia —*Nitrosomonas* / DCD→ Nitrite → Nitrate

(3)Controlled- or slow- release of nutrients due to solubility of product

NBPT (Urease inhibitor) +**DCD** (Nitrification inhibitor)

Microthin Polymer coating



Objective

- To observe the potential of EEFs in maintaining the yield and quality of irrigated, late sown russet potatoes
- To determine the effectiveness of EEFs in reducing N losses throughout the growing season

Materials and Methods

N Treatment	N Source	Starter	Timing	Rate (kg N/ acre)	Total N
Control	_	_	_	0	0
Growers' Standard		10-34-0	Planting	34	280
	Urea	-	Hilling	168	
	UAN	-	Tuber Initiation	78	
Urea	Urea	-	Planting	225	225
UreaSplit	Urea	-	Planting	112	280
	Urea	-	Hilling	168	
SuperU	SuperU	-	Panting	112	280
	SuperU	-	Hilling	168	
ESN	ESN	-	Panting	112	280
	ESN	-	Hilling	168	

Cultivars
1. Russet Burbank (Indeterminate)
2. Dakota Trailblazer (Indeterminate)
3. ND8068-5 Russ (Determinate)

Experimental Design- Factorial Randomized Complete Block Design
Replicate- Four

AGRONOMIC PARAMETERS

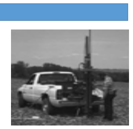
1. Yield and Grade* 2. Specific gravity* 3. N uptake 4. Apparent fertilizer recovery 5. Petiole Nitrate 6. NDVI

N LOSS ASSESSMENT

NH_3 volatilization*

N_2O emission*

Lysimeter NO_3^-



Residual NO_3^- *

* Parameters discussed

Results and Discussion

Table 1: Yield and specific gravity in 2015 and 2016

N treatment	Total tuber yield (Mg ha^{-1})	Marketable yield (Mg ha^{-1})	Specific gravity
2015			
Grower's	48.7 (1.40)ab	39.8 (1.33)bc	1.094 (0.002)
Urea	50.4 (0.83)a	42.3 (0.29)a	1.099 (0.003)
UreaSplit	46.7 (0.85)b	39.2 (0.66)c	1.097 (0.002)
SuperU	46.7 (0.84)b	38.2 (0.91)c	1.092 (0.001)
ESN	49.9 (0.74)a	41.6 (0.85)ab	1.094 (0.003)
Control	43.4 (0.79)c	36.1 (0.87)d	1.082 (0.011)
Cultivar			
Russet Burbank	48.4 (0.60)a	38.8 (0.65)b	1.086 (0.004)
Dakota Trailblazer	45.9 (0.73)b	39.2 (0.65)ab	1.096 (0.004)
ND 8068-5 Russ	48.6 (0.65)a	40.6 (0.86)a	1.097 (0.004)
	Analysis of variance		
N treatment	***	***	NS
Cultivar	**	*	NS
N treatment × Cultivar	*	***	NS
2016			
Grower's	49.7 (1.60)a	34.7 (1.86)bc	1.100 (0.003)
Urea	46.5 (1.83)b	33.6 (0.89)c	1.102 (0.002)
UreaSplit	48.7 (2.14)a	37.5 (1.94)a	1.102 (0.003)
SuperU	49.1 (2.39)a	37.2 (2.83)ab	1.099 (0.003)
ESN	50.0 (2.44)a	38.7 (1.69)a	1.098 (0.003)
Control	40.0 (1.21)c	25.0 (1.60)d	1.103 (0.003)
Cultivar			
Russet Burbank	55.2 (1.16)a	37.4 (1.68)a	1.094 (0.001)c
Dakota Trailblazer	45.7 (0.89)b	37.9 (1.69)a	1.110 (0.001)a
ND 8068-5 Russ	41.9 (0.57)c	28.9 (1.70)b	1.098 (0.001)b
	Analysis of variance		
N treatment	***	***	NS
Cultivar	***	***	***
N treatment × Cultivar	***	***	**

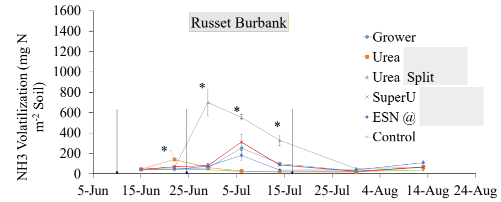


Fig 1. NH_3-N emission throughout the growing season of 2015 in Russet Burbank cultivar. **Cumulative NH_3-N emissions were calculated by summing up emissions of each sampling days**

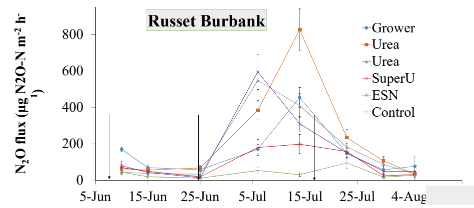
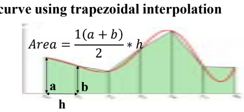


Fig 2. N_2O-N fluxes on each sampling day in 2015 growing season in Russet Burbank cultivar. **Cumulative N_2O-N emissions were estimated by calculating the area under the curve using trapezoidal interpolation**



Trapezoidal interpolatiom

Table 2: Cumulative NH_3-N and N_2O-N losses in 2015 and 2016

	Cumulative emissions (kg ha^{-1})			
Source of Variation	NH_3-N		N_2O-N	
N treatments	2015	2016	2015	2016
Grower's	6.07 (0.86)b	4.14 (0.95)b	2.28 (0.29)c	2.53 (0.15)b
Urea	3.54 (0.23)c	2.13 (0.17)c	2.93 (0.28)a	1.74 (0.09)c
UreaSplit	20.0 (1.42)a	7.28 (1.66)a	2.72 (0.18)ab	2.95 (0.31)a
SuperU	5.97 (0.77)b	2.61 (0.28)c	1.37 (0.08)d	1.72 (0.15)c
ESN	3.53 (0.47)c	2.59 (0.40)c	2.36 (0.18)bc	2.02 (0.14)c
Control	2.45 (0.29)c	1.84 (0.13)c	0.69 (0.06)e	0.33 (0.01)d
Cultivar				
Russet Burbank	6.97 (1.30)ab	4.82 (1.11)a	2.39 (0.26) a	1.81 (0.23)ab
Dakota Trailblazer	8.10 (1.80)a	2.73 (0.30)b	2.13 (0.23) a	1.76 (0.17)b
ND 8068-5 Russ	5.70 (1.45)b	2.76 (0.22)b	1.67 (0.17) b	2.07 (0.27)a
	Analysis of variance			
N treatment	***	***	***	***
Cultivar	**	***	***	*
N treatment × Cultivar	NS	***	NS	***

Table 3: Cumulative NH_3-N and N_2O-N losses in 2015 and 2016

	Residual NO_3-N in soil (kg ha^{-1})	
N treatments	2015	2016
Grower's	43.3 (1.33)b	59.6 (10.7)a
Urea	26.0 (2.58)c	37.2 (5.27)bc
UreaSplit	39.7 (3.94)b	52.6 (7.36)ab
SuperU	74.2 (1.74)a	66.2 (14.1)a
ESN	22.2 (1.53)cd	53.4 (6.85)ab
Control	14.7 (0.91)d	26.4 (2.60)c
Cultivar		
Russet Burbank	29.4 (3.79)b	34.6 (3.62)c
Dakota Trailblazer	41.2 (6.42)a	50.1 (3.66)b
ND 8068-5 Russ	39.4 (5.48)a	63.0 (9.34)a
	Analysis of Variance	
N treatment	***	***
Cultivar	***	***
N treatment X Cultivar	**	*

- Target yield (62 Mg/ha) could not be obtained due to rainfall delay in planting. In 2015 no yield benefit over 225 kg N/ ha (Urea) was obtained because the growing season was shorter (114 days) compared to that of 2016 (126 days). However in 2016 yield of ESN consistently maintained the yield in both growing season by supplying N to plant according to demand through its slow release mechanism. N release from SuperU did not match with plant N demand, so could not increase yield over un amended urea when applied at same rate (280 kg N/ha). In a shorter growing seasons, determinate (early maturing) cultivar (ND8068-5 Russ) can compete with commercial indeterminate (Russet Burbank) cultivar. Indeterminate cultivars need a full growing season (125-130 days) to perform with full potential. Both years specific gravity reached the processing quality standard and were not influenced by N treatments.
- Cumulative NH_3 volatilization increased tremendously with UreaSplit, especially after second split application due to quick urea hydrolysis and NH_3 formation. When applied at same rate (280 kg N/ ha) EEFs reduced NH_3 volatilization compared to Urea.
- Cumulative N_2O emissions were also reduced with EEFs compared to urea (280 kg N/ha). SuperU was more effective in reducing N_2O emission as it delays nitrification thus prohibiting N_2O emission via nitrification and denitrification.
- Residual NO_3^- tremendously increased with SuperU as the N mineralization was very slow and did not synchronize with plant N uptake and finally leached beyond root zone with irrigation and rainfall.
- Cultivars respond differently regarding N losses and yield. Cultivar responses are greatly influenced by the growing season condition. The growth stage duration and vine type are the most important regulating factor for variability in cultivar response, however root morphology and root depth of the cultivars are needed to be studied in future

Conclusion

- ESN can be a smart choice to reduce N losses, environmental hazards along with consistent performance in maintaining yield.
- Determinant cultivars like ND8068-5 Russ can be useful in shorter growing seasons.
- A different fertilizer program should be developed for the determinant cultivars.