Increasing late N availability throughout new products to soybean crops - Season 2009-2010

Fluid Fertilizer Foundation

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Introduction

This report show the results of a second set of site trials designed to evaluate the response to applied N to soybean. Soybean as all other legumes satisfies their needs of N by biological fixation (BF) through a symbiotic association with Rhizobia. As other controversial issues on production agronomy, it is hypothesized that soybean under a potential high yielding environment may suffer some N shortage because BF do not deliver sufficient N to filling grains. This is the same as underutilizing production factors, like light and moisture, under the actual breeding advances due to insufficient N supply by BNF.

The current advances of controlled release fertilizers that allow sometime between the application and the availability of N to crops could be advantageously used to provide an enhanced late N supply to soybean and so increase grain yields. Those N controlled release products can be applied by fluid equipment during early stages of growth synchronized with the herbicide application for weed control.

The results of the experiments shown in this report had the objective to evaluate the effect of increasing late N availability by improving placement/product combinations of fluid N sources on soybean grain yields and N uptake.

The need of good yield potential to express N response could be achieved under a good weather scenario, that was not possible during the last first season. We present the results of the second year of the experiments and a brief discussion in light of a combined analysis pooling these results along with the first season 2008-09.

Materials and Methods

One experiment was conducted in the 2009-2010 season with soybean and carried out at four locations. The experiments were in farmer’s fields and experimental station of INTA at Pergamino. The locations where the trials on wheat were installed were: Mercedes (Corrientes Prov.), Crespo (Entre Rios Prov.) Pergamino (Buenos Aires Prov.) and Acevedo near this last location. The experiment located in the experimental station of INTA, at Mercedes failed due to the flooding after intensive rains after sowing and before emergence.

Although the locations of the experiment are the same as presented in the 2009 report, the sites differed. The tables 1 and 2 below show some agronomic characteristics and soil test values of the top 0-20 cm.

Table 1. Soil fertility characteristics of topsoil of the experimental sites.

Site	*Location*	*pH*	*OM*	*P-Bray*	*S-SO4*
			%		
Crespo	Entre Rios	6,3	3,15	11,3	12,4
Pergamino	NO Bs.As.	5.9	2.54	23.5	17.0
Acevedo	NO Bs.As.	6,1	3,13	11,9	16,6

Table 2. Agronomic characteristics and management dates of the experiments.

Site	Previous crop	Variety /Hybrid	Sowing Date	Starter N-P-K-S
Crespo (ER)	Soybean 1st	A 4404RG	Nov -22	0-30-0-15
Pergamino (Bs.As.)	Corn	A 4613	Oct 27	0-0-0-12
Acevedo (Bs.As.)	Soybean 1st	A4613	Dec-12	11-52-0-0

As reported in 2009, the experiment evaluated four N combinations of source/placement treatments that were compared with a check that did not receive fertilizers and with a control that received a readily available N source (ammonium nitrate: 33-0-0) applied at R1 stage, making a total of ten treatments.

The evaluated sources were slow or controlled release N products, as follow:

- Nitamin®, provided by GPA, a fluid fertilizer with 30 % N, of which 60 % is slow release, and 40 % of N is in amidic form (urea);
- Nitamin Nfusion ™, provided by GPA[1], a fluid fertilizer with 22 % N, of which 94 % is slow release and the rest being urea;
- A concentrated urea solution (20% N);
- Idem but with the addition of 0.5% of Agrotain®[2], (n-BTPT, an urease inhibitor);

Fluid applications were performed by two methods: 1) Dribbling and 2) Knifing in subsurface bands. A mechanical pump and an applicator bar that holds the nozzles and hoses that deliver the fertilizer blend stream every 0.52 m across the width of the plots at a speed proportional rate by pumping through a hose that fall freely over the soil or is attached to a knife that lead the fluid at 5 cm below soil surface. The rate for all N applications was 40 kg N/ha.

All these sources were applied and placed at the best timing in order to minimize the possibility of interfering with the symbiotic process. Thus, Urea solutions (c & d) , Nitamin ® (a) and Nitamin NFusion™ (b) were knifed and placed at 5 cm below and aside the rows (2” x 2”) at V3 stage. A summary of the treatments are shown in the table 3.

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[1] GPA: Georgia Pacific Ltd. Atlanta GA

[2] Agrotain Internacional, St. Louis, MO

Table 3. Summary of the 40 kg N/ha applied in the different treatments.

	Treatment	% N	Timing	Placement
1	*Check (No N Fertilizer)*	--	--	--
2	*Control (Ammonium Nitrate)*	33	R1	Broadcast
3	*Nitamin®,*	29	V3	Knifed 5 cm x 5 cm
4	*Nitamin Nfusion*	27	V3	Knifed 5 cm x 5 cm
5	*Urea solution*	22	V3	Knifed 5 cm x 5 cm
6	*Idem 5 + 0.5% of Agrotain®*	22	V3	Knifed 5 cm x 5 cm
7	*Nitamin®,*	29	V3	Dribbled
8	*Nitamin Nfusion TM*	27	V3	Dribbled
9	*Urea solution*	22	V3	Dribbled
10	*Idem 5 + 0.5% of Agrotain®*	22	V3	Dribbled

All these treatments were allocated in a randomized block design with four replications. Plots will be 6 or 8 rows spaced 0.52 m (or 0,70 m in Crespo) of 10 m length.

The crops were inoculated and properly fertilized at planting with enough P and S to prevent any possible shortage of essential nutrients (Table 2).

At R5-R6 stage, ten plants were sampled for aboveground biomass production and N content in biomass, so that we can have an estimation of N uptake by combining both numbers. Plants were cut aboveground, weighted, chopped and sampled to send in laboratory for water and N content analysis.

Grain harvest was made at physiological maturity and yield was evaluated by cutting plants of four lineal segments within the plot, each one covering 0,5 m2 making a total area of 2 m^2. The whole aboveground plants were weighed before threshing to evaluate total aboveground dry matter. After threshing, a sample of grain and residues was taken to evaluate humidity content in grain and stover. Plot grain yield was expressed in kg/ha at 13,5 % humidity

Grain analyses for N concentration were performed using Kjeldhal technique and protein was calculated used a local factor of 5,71. Nitrogen uptake by grain in kg /ha was calculated as a product of grain yield and N concentration. By subtracting the values of the check, the partial N efficiency for each of the treatment was calculated as increase in grain N accumulation that results from the application of a given rate of fertilizer N.

Statistical Analysis

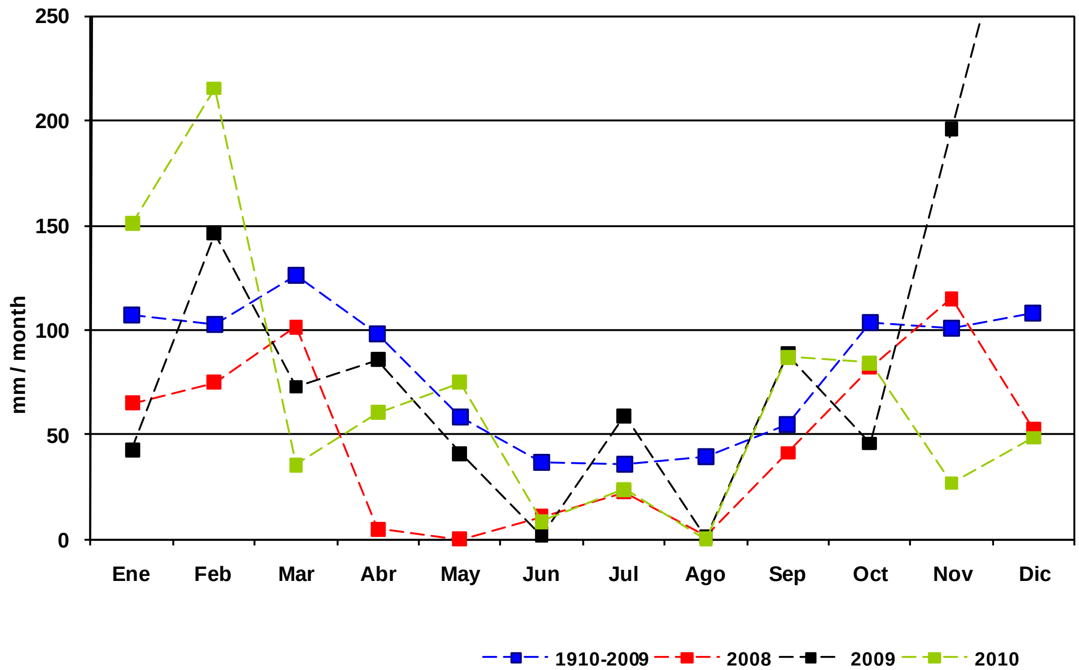
The soybean yield data was statistically analyzed considering the site and treatment and its interaction as well according to the following model: $Y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + \gamma_k + \alpha\gamma_{ik} + \varepsilon_{ijk}$

Where μ is the overall mean and ε is the experimental error, α, β, and γ are estimators for the site, block and treatment effects respectively. When grain yield were analyzed by site, the corresponding effect and its interactions were withdrawn from the model. Some treatments comparisons were performed as single orthogonal contrast. All data were analyzed using the general lineal model procedures of the SAS statistical software (SAS Institute Inc., 1999-2001).

Results and discussion

Unlike the 2008-2009 season, the prevailing weather scenario was much better with abundant and opportunistic rains. The figure 1 show the accumulated rainfall compared to past year and normal long term climatic series, during the growing time of the soybean crops.

Figure 1. Moontly precipitation of 2008 thru 2010 , and long term (1910-2009) serie at INTA Exp. Stations of Pergamino. (Dec 2099 : 330 mm)



The nodulation expression was checked at early stages of v2-v3, before N applications in all sites by sampling randomly around 10 plants in the site with no signs of limitations of any kind that could have affected N supply to crops. Thus, it is assumed that N fixations performed very well.

The grain yields in general were higher than past season at the same locations due to the better rainfall. But there were strong differences in yield among sites due to the weather and other site characteristics. The sites differed statistically (pr > F = <.0001) but there were not interactions between treatments and sites, (pr > F : 0.5276) indicating a similar performance across the sites. The highest yield was in Acevedo with average of 4,303 kg/ha and the lowest in the nearby Pergamino (2,865 kg/ha), which could be explained by a later sowing time. Average crop yield in Crespo was similar to Pergamino; although the sowing was somehow earlier, this site had less yield potential, which were magnified by extreme rainfall in November (428 mm).

The table 4 and 5 present the grain and biomass yields by site with a summary of the statistical analysis. In spite of the differences in sites, some tendency is observed with sources and incorporation of fertilizers (Fig 2). In general the grain yields and differences due to treatments, were paralleled with biomass yield early stages (R5-R6). There were some treatment differences, but although weak, the higher contrast was observed between the check and the fertilized treatments with either combination of product and way of application.

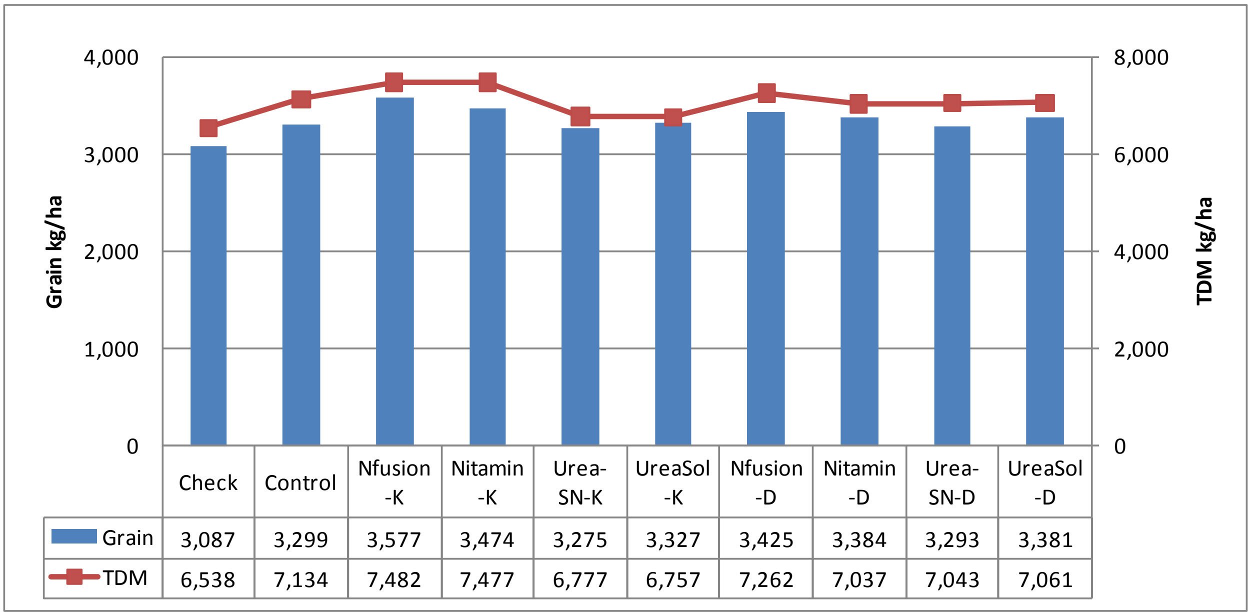
Table 4. Treatment means and summary of statistical analysis for soybean grain yields across sites in 2009/10.

Treatment / Placement	Pergamino		Acevedo		Crespo	
					Kg /ha	
Check - No N --	2.861	A	3.877	B	2.522	B
Control – AN Broadcast	2.714	A	4.161	AB	2.878	A
Nfusion Knifed	2.874	A	4.694	A	2.855	A
Nitamin Knifed	2.898	A	4.811	A	3.020	A
Urea solution Knifed	2.900	A	4.205	AB	2.878	A
Urea Sol + n-BTPT Knifed	2.854	A	3.917	B	3.055	A
Nfusion Dribbled	2.967	A	4.337	AB	2.847	A
Nitamin Dribbled	2.969	A	4.423	AB	2.882	A
Urea solution Dribbled	3.108	A	4.234	AB	2.801	AB
Urea Sol + n-BTPT Dribbled	2.502	A	4.367	AB	3.011	A
Pr> $F_{treatment}$	0.37		0.13		0.08	
$LSD_{5\%}$	772		647		306	
CV %	18.6		10,33		7.4	

Table 5. Treatment means and summary of statistical analysis for total aboveground dry matter yields across sites in 2009/10.

Treatment / Placement	Pergamino	Acevedo	Crespo
		Kg ha-1	
Check - No N --	6,182	8,349	5,082
Control – AN Broadcast	5,953	9,288	6,161
Nfusion Knifed	6,116	10,402	5,915
Nitamin Knifed	5,873	10,468	6,107
Urea solution Knifed	5,848	8,936	5,487
Urea Sol + n-BTPT Knifed	6,051	8,428	5,853
Nfusion Dribbled	5,872	9,507	5,733
Nitamin Dribbled	5,775	9,603	6,408
Urea solution Dribbled	6,069	9,016	6,099
Urea Sol + n-BTPT Dribbled	5,200	9,361	6,566
Pr> $F_{treatment}$	0.9728	0.1276	0.0245
$LSD_{5\%}$	1500.9	1568.6	777
CV %	17.6	11.6	9.0

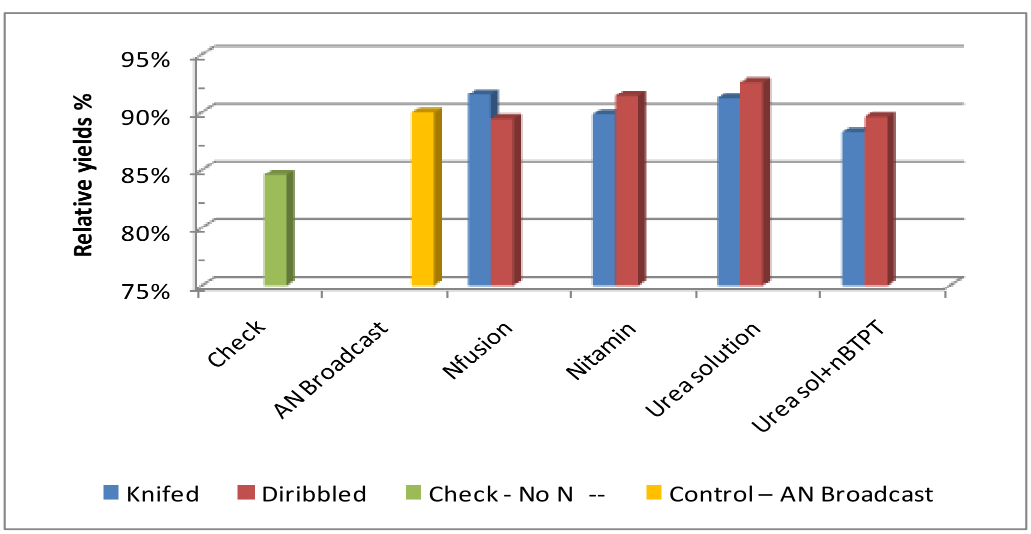
Fig. 2. Treatment means pooling locations for grain and total dry matter yields.



The gain in grain yield through N fertilization is of a few magnitudes, ranging between 0 to 16 % , or 0, 470 and 390 kg/ha in Pergamino, Acevedo and Crespo. The bigger and lower increase are on the sites with the highest and lowest yields, supporting the hypotheses that a complement of applied N help to get higher yields where the N supply by biological fixation could not satisfy the requirements, and is superfluous where yield is limited by any other reason.

Regarding grain referred as relative yields when pooling all sites, season and locations, the increase over the check range between 5 to 7 % , with few if any differences between fertilized treatments (Fig. 3).

Fig. 3. Treatment means differences of relative yields across location and years. Seven trials 2008-2010).



A variable trait quite more affected by fertilizer treatments were protein content in grains. The table 5 shows the treatment means of protein concentration in grain of each site. The values show a good tendency in sources for both dribbled and knifed method of application, which is consistent across seasons (Fig. 4). Control treatment that received AN show a rather high level comparable to better treatments. On the other hand, the check depicts a rather low value.

As with the last year data set, there were a negative correlation between the grain yields and protein content of grains, that is higher protein with lower yields (r = - 0,71 *). However, the relationship is not clear when sites are plotted each other. The Fig. 5 illustrates the relationship between protein and yield and each year-site trial appear as a cluster well differentiated from the others.

Table 5. Treatment means of soybean protein content across locations. Each number is a single composite sample of grains of the four replications. Season 2009-2010.

2010	Acevedo	Pergamino	Crespo	Mean
	.... % Protein		....	
Check	*37.5*	*39.5*	*36.4*	*37.8*
Control	*38.1*	*39.9*	*38.8*	*38.9*
Nfusion-K	*38.7*	*40.1*	*38.5*	*39.1*
Nitamin -K	*37.5*	*40.0*	*39.7*	*39.1*
UreaSol-K	*36.6*	*39.3*	*38.8*	*38.2*
Urea-SN-K	*37.0*	*39.4*	*39.2*	*38.5*
Nfusion-D	*36.5*	*39.9*	*39.6*	*38.7*
Nitamin-D	*37.7*	*39.5*	*38.7*	*38.6*
UreaSol-D	*34.7*	*38.9*	*39.5*	*37.7*
Urea-SN-D	*37.1*	*40.2*	*39.4*	*38.9*

Fig. 4. Treatment means pooling locations for protein content in soybean for 2008 and 2009 experiments.

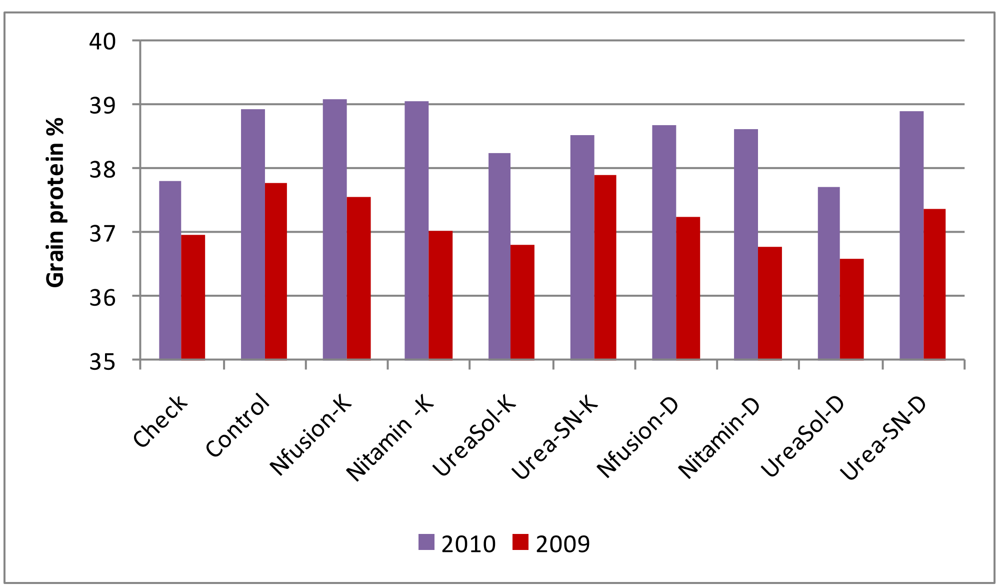
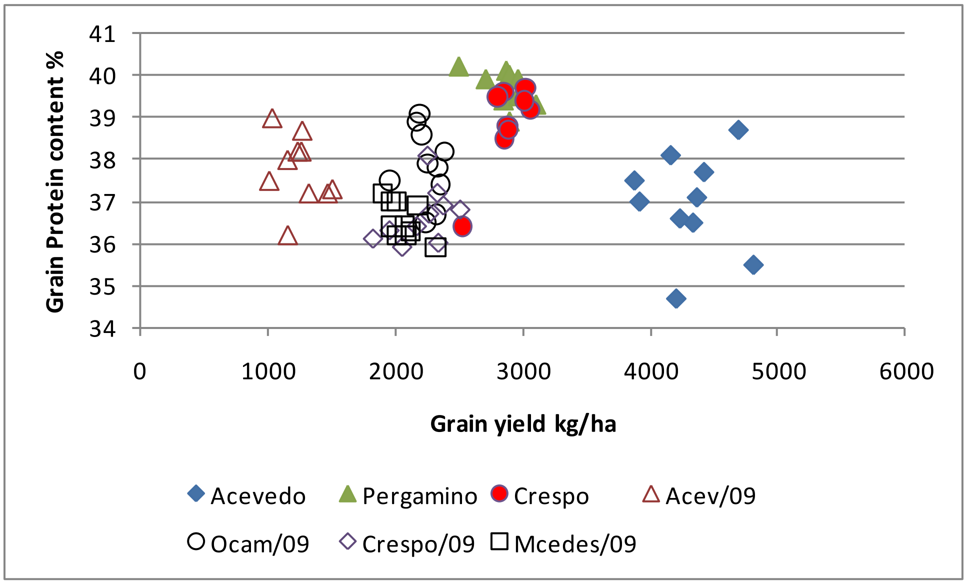
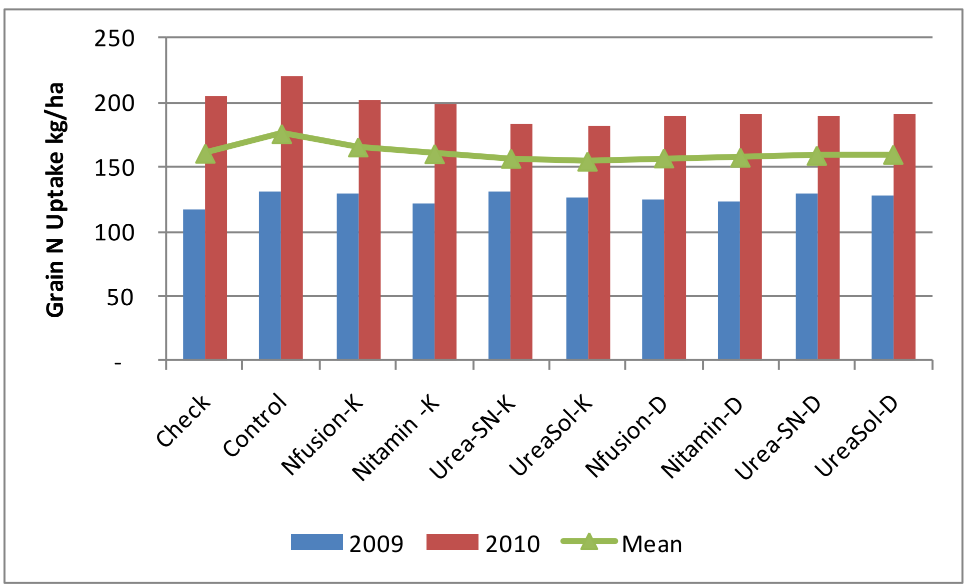


Fig. 5. Grain protein content as related to grain yield for each year-site trial.



When transforming the protein values into N%, and estimating the N uptake in grains, the trend reverse, since yields weight more in the product with protein. Thus the tendency of grain N uptake in differences among treatments is diminished (Fig. 6). As a result, N uptake in grains on the check seems similar to those of fertilized treatments.

Fig. 6. Treatment means pooling locations for grain N uptake in soybean.



Final considerations

The 2009-10 season provided soil moisture conditions to express high yielding potential to soybean crops unlike the past year.

The gains in grain yield due to applied N, although marginal are consistent, but none can be said about differences between treatments or ways of applications.

Neither can be distinguished between the immediate or late N availability. Some treatments allowed for a rather quick availability and others might need some time to mineralize and become available for the soybean crop. Lack of differences between treatments precludes any speculation on this issue.

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