Liming Indexes for Soybean in Established No-Till Systems

By Antonio Nolla and Ibanor Anghinoni

Researchers re-examine the definition of lime requirements for well established no-tillage systems or for those directly established from previously uncultivated natural grasslands.

Conventionally tilled soils being converted into no-tillage production systems, or natural grasslands being directly converted into no-till, tend to accumulate large amounts of crop residue. Within a short period of time, they can also develop strong pH and nutrient (i.e., P, K, Ca, and Mg) gradients. In concert, these changes within the topsoil will act to decrease the potential for Al toxicity through increased complexation with fulvic and humic acids derived from soil organic matter, and low molecular weight ligands resulting from further crop residue decomposition. Other observed changes include decreased exchangeable Al and Al saturation on the CEC, decreased Al activity within the soil solution, and increased soil P availability.

In no-till systems, high yields are possible even under strongly acidic soil pH conditions. There is a strong possibility that adoption of liming criteria designed for systems under conventional soil tillage can over-estimate the lime requirement for established no-tillage systems in southern Brazil. Another important challenge for these no-tillage systems is the identification of an appropriate soil layer thickness, and soil sampling frequency, to be used for assessing topsoil acidity. The depth of soil pH and nutrient gradients does increase with time as more plant residues are deposited and surface applications of lime and fertilizers continue under no-till. When climate and soil conditions favor corrective action, surface application of lime can correct soil acidity within the top 10 cm up to 4 years after lime application (Miyazawa et al., 1993; Franchini et al., 1999; Anghinoni and Salet, 1998).

This study explored various options for liming indexes in soybean after 8 years of no-tillage in an acid clayey Oxisol previously under conventional tillage, and before that, natural grassland. Three levels of lime were applied at the establishment of the conventional tillage cropping system. Soil sample results after 8 years of no-till still present a wide range of soil acidity indexes (**Table 1**).

Liming criteria, the values indicating the necessity for lime, were established according to the relationship between soybean yield and six indexes using two soil depths, 0 to 10 cm and 0 to 15 cm. All relationships were significant regardless of soil depth or initial soil condition prior to no-till establishment (**Figure 1A and 1B**). The comparison between soil sample depths found better relationships with soybean yields using the 0 to 15 cm soil layer, despite the larger range of the acidity parameters found in the 0 to 10 cm soil layer.

All the response curves, except exchangeable Al/Ca + Mg, were curvilinear, with very good fitness and significance. The exchangeable Al/Ca + Mg relation was linear, and was not further considered as a suitable lime index in this present work. The resulting liming criteria obtained for both initial tillage conditions are provided in **Table 2**. The average acidity

Liming requirements for soybean in conventional tillage may be higher than for established no-till systems in southern Brazil.

indexes values for the 0 to 15 cm soil layer can be considered lower than current liming criteria values for soybean in Brazil. It is apparent from these results that exchangeable Al can be considered less toxic to soybean within a no-tillage system.

Currently, the 0 to 10 cm layer is the recommended soil sample depth for determining lime surface application within well established no-till fields in southern Brazil. It is important to consider that two of the three more commonly used liming criteria in Brazil [i.e., pH (water) and base saturation], were very similar when evaluated either in the 0 to 15 cm or 0 to 10 cm soil layer. However, the indexes for exchangeable Al and Al saturation were considerably higher in the 0 to 15 cm layer as compared with the 0 to 10 cm layer, which presented higher variability.

Table 1. Range of soil chemical attributes in the 0 to 20 cm soil layer after 8 years under no-tillage after application of lime.

Chemical attribute	Initial condition	Range
Water pH	Conventional tillage	4.3 to 5.5
	Natural grassland	4.1 to 5.7
$CaCl_2$ pH	Conventional tillage	3.6 to 4.8
	Natural grassland	3.3 to 5.1
Exchangeable Al, $cmol_c$/kg	Conventional tillage	2.5 to 0.2
	Natural grassland	2.9 to 0.5
Bases saturation, %	Conventional tillage	16 to 61
	Natural grassland	11 to 71
CEC[1], $cmol_c$/kg	Conventional tillage	12.4 to 14.6
	Natural grassland	13.0 to 16.2

[1]CEC estimated by 0.5 mol/L calcium acetate method.

Abbreviations and notes for this article: P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; Al = aluminum; CEC = cation exchange capacity.

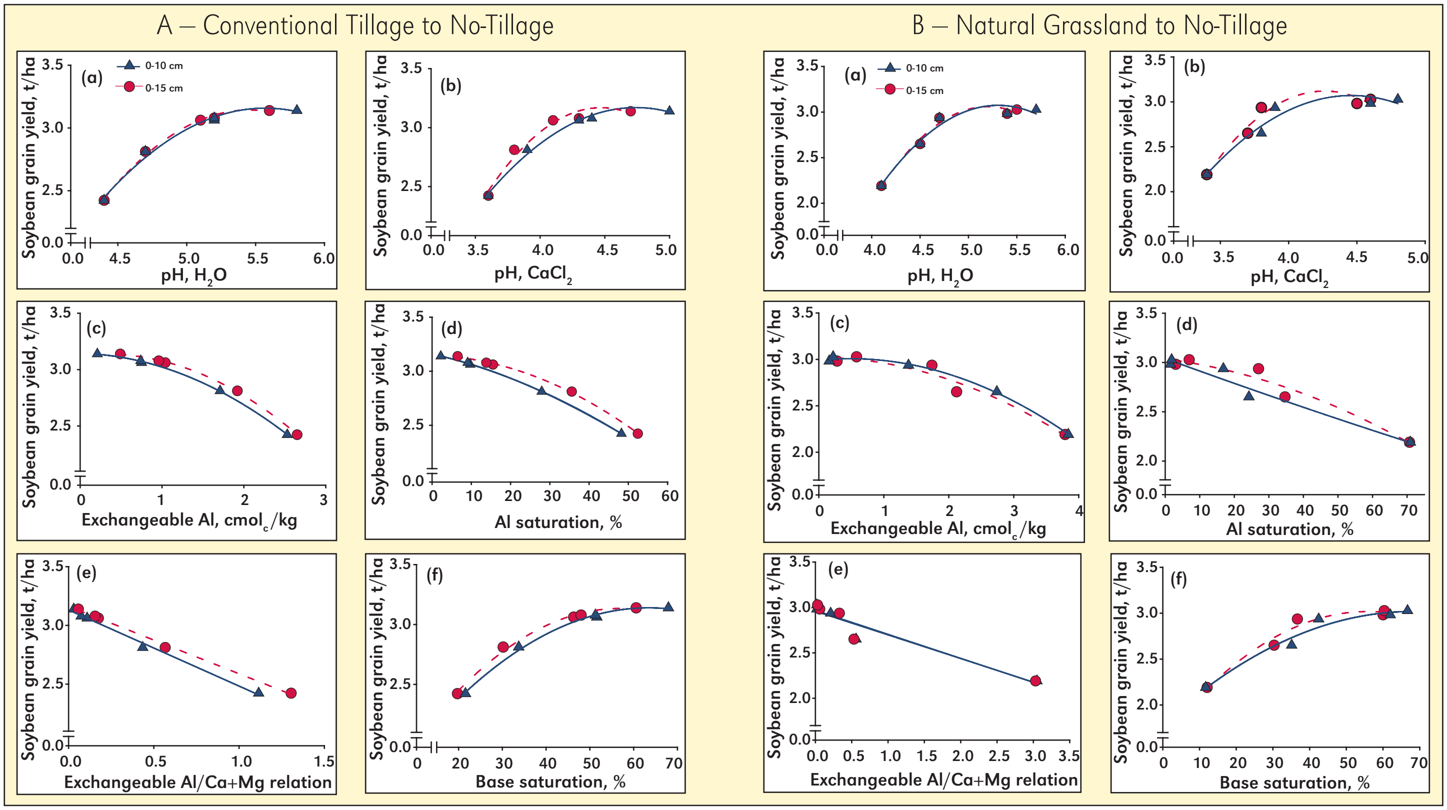

Figure 1. Relationship between soybean grain yield and pH H_2O (a), pH $CaCl_2$ (b), exchangeable Al (c) Al saturation (d), exchangeable Al/Ca+Mg relation (e), and base saturation (f) in two layers of soil under no-tillage for 8 years after application of lime rates in conventional tillage (A) and in natural grassland (B).

Liming criteria as determined by the 0 to 15 cm sample depth and both Al indexes were particularly more variable between the conventional tilled and natural grassland sites. Higher reference values for the latter case can be related to the site's direct conversion to no-till, which has maintained soil acidity characteristics more in line with those measured prior to the adoption of no-till.

In a related greenhouse study designed to determine if liming criteria could be established within a short-term experiment, undisturbed soil samples were collected from the field site using columns. Soybean growth behavior in the greenhouse, as affected by soil acidity, was similar to that observed for grain yield results obtained from the field. Relationships between soil acidity and soybean root and shoot growth were also curvilinear, with good fitness for all acidity indexes, in both soil layers, and initial soil condition prior to no-till (data not provided). Liming criteria were then determined (**Table 2**), which compared well with those obtained from the field experiment. However, it is important to note that the lime criteria based on root growth was most similar to results obtained in the field.

The soil sample depth for lime requirement determination

Table 2. Liming criteria for soybean based on different soil acidity indexes, and two soil sampling depths after 8 years of no-tillage.

Parameter	Initial condition	pH-H_2O		pH-$CaCl_2$		Exchangeable Al, $cmol_c/kg$		Al saturation, %		Bases saturation, %	
		0 to 10[2]	0 to 15	0 to 10	0 to 15	0 to 10	0 to 15	0 to 10	0 to 15	0 to 10	0 to 15
Grain yield	Conventional	5.6	5.5	4.7	4.5	0.29	0.32	3	11	64	60
	Natural grassland	5.3	5.2	4.5	4.3	0.47	0.79	3	23	60	62
	Average	5.5	5.4	4.6	4.4	0.38	0.56	3	17	62	61
Root biomass[1]	Conventional	5.6	5.4	4.8	4.5	0.31	0.68	13	11	61	55
	Natural grassland	5.7	5.1	4.8	4.2	0.31	1.11	1	16	75	61
	Average	5.7	5.3	4.8	4.4	0.31	0.90	7	13	70	58
Root length[1]	Conventional	5.5	5.7	4.7	4.7	0.64	0.74	10	10	59	63
	Natural grassland	5.4	5.2	4.5	4.3	0.13	0.85	9	13	80	57
	Average	5.5	5.5	4.6	4.5	0.39	0.80	10	12	69	60
Shoot biomass[1]	Conventional	5.4	5.3	4.6	4.4	0.53	0.80	1	14	56	63
	Natural grassland	5.3	5.1	4.4	4.2	0.96	0.89	1	14	47	61
	Average	5.4	5.2	4.5	4.3	0.75	0.85	1	14	52	62

[1]Determined using undisturbed soil core samples and soybean grown under greenhouse conditions.
[2]Soil layer depth, cm.

IPNI Crop Nutrient Deficiency Photo Contest—2007

While the classic symptoms of crop nutrient deficiencies are not as common in fields as they were in the past, they do still occur. To encourage field observation and increase understanding of crop nutrient deficiencies and other conditions, the International Plant Nutrition Institute (IPNI) is sponsoring a photo contest during 2007.

"We hope this competition will appeal to practitioners working in actual production fields," said IPNI President Dr. Terry Roberts. "Researchers working under controlled plot conditions are also welcome to submit entries. We encourage crop advisers, field scouts, and others to photograph and document deficiencies in crops."

Some specific supporting information is required for all entries, including:

- The entrant's name, affiliation, and contact information.
- The crop and growth stage, location, and date of the photo.
- Supporting and verification information related to plant tissue analysis, soil test, management factors, and additional details that may be related to the deficiency.

There are four categories in the competition: Nitrogen (N), Phosphorus (P), Potassium (K), and Other. Entries are limited to one per category (one individual could have an entry in each of four categories).

Cash prize awards are offered in each of the four categories as follows:

- First place = US$150
- Second place = US$75
- Third place = US$50

Photos and supporting information can be submitted until the end of calendar year 2007 (December 31, 2007) and winners will be announced in January of 2008. Winners will be notified and results will be posted at the website.

Entries are encouraged from all regions of the world. However, entries can only be submitted electronically as high resolution digital files to the organization's website, at **>www.ipni.net/photocontest<**.

For questions or additional information, please contact:

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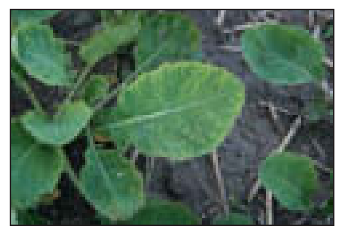
Shown at right are some photos as examples of deficiency symptoms. BC

Nitrogen deficiency in corn.

Phosphorus deficiency in cotton.

Potassium deficiency in soybeans.



Sulfur deficiency in canola.

in well established no-tillage systems converted from conventional tillage or natural grassland can be either 0 to 15 cm or 0 to 10 cm. Among the tested acidity indexes, pH (water) and percent base saturation were most suitable in assessing the lime criteria for soybean. Reference values from this research are lower than those currently being recommended. The lime criteria for no-tilled soils can also be quantified within short term experiments using undisturbed soil samples and soybean root growth parameters. BC

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