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ROLE OF SOIL TESTING

IN SITE-SPECIFIC NUTRIENT MANAGEMENT

Adrian M. JOHNSTON

PPIC, CANADA

Potash & Phosphate Institute of Canada (PPIC)
Suite 704, CN Tower
Midtown Plaza
Saskatoon, SK S7K 1J5
Canada
E-mail: ajohnston@ppi-ppic.org

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Role of Soil Testing in Site-Specific Nutrient Management

Adrian M. JOHNSTON
Potash and Phosphate Institute of Canada (PPIC)

Soil testing is an important diagnostic tool for making informed nutrient management decisions in agriculture. By having a means of evaluating the soil nutrient status the farmer is better equipped to determine which nutrients, and in some cases what rates of nutrients, are required to achieve an established yield goal (Johnston, 2004). While other means of evaluating soil fertility at a site are available, none provide the rapid response obtained with a soil test that most farmers usually demand. The objective of this paper is to discuss soil nutrient assessment methods by soil testing currently being used by staff working with the IPNI (formally PPIC in Asia). These methods have the same basic objective – to provide the farmer with nutrient recommendations which help in achieving desired yield goals.

Why soil test?

Farmers generally view soil testing as a means of helping establish recommended rates of nutrient application. However, soil testing provides us with some important soil diagnostic information.

1. Soil testing helps to establish the nutrient status of a field. This is important as it provides guidance to the farmer, and/or his advisor, on what nutrients are low, medium or high in availability. This information then helps in determining what would be required to change the current production level of the field.
2. Soil testing also helps to identify which elements are missing from the soil, or deficient at a level that may limit productivity. Often a soil test is first used when a production problem is identified, and can help to show why yields are lower than expected. An example of this is low sulphur (S) and zinc (Zn) in soils in India – testing for these nutrients revealed that S and Zn deficiencies were limiting response to nitrogen (N), phosphorus (P) and potassium (K).
3. From an environmental impact point of view, soil testing is critical to avoid over, and under, application of nutrients. In many parts of Asia, N is being over-applied as a means of increasing yields. IPNI research programs have shown a number of times that applications of N, and in some cases N and P, can be reduced when additional K is applied. Overall fertilizer costs go down, and yields go up, simply by balancing the nutrients applied.

Problems/Challenges with Soil Testing

Soil testing is not without its challenges, many of which must be addressed to make the process effective for the farmer. Proper soil sample collection and handling, selection of a suitable extraction method, how the sample results are interpreted, and the type of recommendation philosophy used by the lab (if at all considered by the farmer) are all factors to consider.

- Most soil testing labs provide excellent guidelines on how samples should be collected and handled in transit to the lab. Ensuring the lab knows the sample depth submitted is very important when the nutrient content is calculated. Most samples which must travel any distance require that they be dried prior to shipping. Additional details on the sample collected should also be communicated to the lab either on the sample box or information sheets submitted with the sample.

- Labs will either use a number of extraction solutions or in some cases a single solution, to evaluate soil nutrient content. In most cases, the lab will ensure that where sample pH is going to influence the result obtained, the appropriate extractant will be used in the analysis. However, some labs offer either a common extractant, or have a specific extractant they use for soil analysis, and in these cases the farmer and/or agronomist need to be aware if this is suitable for the soils submitted.
- The interpretation of results usually involves the determination as to whether the sample nutrient content is low, medium or high, for a given crop and yield goal submitted with the sample. For some labs this interpretation comes from a database of field trial results. Another method is to use crop uptake/removal requirements to estimate the nutrient needed. And some labs base their interpretation on greenhouse crop response trials, monitoring how specific crops respond to deficiencies of various nutrients. Understanding which method of data interpretation you are getting can often affect the recommendation you will come up with.
- Finally, each lab has a recommendation philosophy by which they interpret your crop nutrient requirements and soil test levels. Some labs have a database of field or greenhouse results for the crop of interest and some history in making recommendations. Others will make recommendations based on the nutrient uptake of a crop, with the actual rate suggested being the difference between the nutrient demand of the target yield and the soil available nutrient supply. Some labs use an elaborate computer program, considering N mineralization, immobilization, nutrient credits, and other factors before coming up with a recommendation. Either method works well – understanding how your recommendation was made is the important point.

Another major challenge with soil testing is finding a suitable lab that offers the service at a price that is acceptable to local farmers. Many farmers in developing countries do not have the resources to pay the cost of completing a soil analysis, and therefore rely on regional recommendations for using fertilizers. In many countries it may be necessary for government agencies and fertilizer dealers to subsidize the cost of soil testing in specific regions to get some region/site specific information on soil nutrient status. However, it is easy to see that samples collected in a region may not address the specific field conditions that a grower may have. This is a dilemma which is likely to continue into the future.

So what can you expect from a soil test?

Soil testing is a scientific tool, which when used properly, can help in making decisions on nutrient recommendations. What we should expect from a soil testing lab is field specific information regarding the soil nutrient supply – nothing more, nothing less. If you agree with the recommendation philosophy used by the lab, then you will also get some nutrient recommendations for the specific crops and yield targets you plan to grow. However, remember that this recommendation will be based on some average used by the lab, and not take into consideration the specific field and management history of a grower or field. In most cases, farmers can do far better if they take the soil nutrient estimate from the lab and use it to develop their own field specific recommendation, often with the help of their local agronomist. This allows the farmer to make adjustments in the nutrient recommendation that will meet his specific needs in each field, and avoids recommendations based on an "average" type of response.

Can soil testing be used to minimize any environmental impact of fertilizers?

There is a lot of talk about Beneficial/Best Management Practices (BMP) these days. In most cases these are focused on how best to manage livestock manure in areas where intensive livestock operations are based on a very limited land base. This scenario, common in North America, has created some localized soil nutrient surplus situations. However, when it comes to managing fertilizer nutrients there is less published information on fertilizer BMPs.

From an agronomic management point of view, the potential fertilizer BMPs which will have some impact include (Johnston, 2006):

- soil testing to establish the soil nutrient supply level,
- using some method to establish the right fertilizer rate for the crop yield targeted,
- selecting the right fertilizer source for the crop and soil management conditions,
- placing fertilizer so as to minimize nutrient losses from the soil – plant system, and
- timing fertilizer application to ensure that the supply of nutrients are available to the crop when they are required.

Of these BMPs listed here, it is soil testing which forms the basis for estimating the right rate of nutrients to apply to a crop. However, do we have any examples of how soil testing is used to prevent over, or under, fertilization? Some examples are given below.

From Southeast China there are a couple of examples where soil testing helped to lower N rates and increase P and K rates to help increase yield (Tables 1 and 2). A classic example of balancing the nutrients applied. The results from Lishi Town also provide some insight into the process of using deletion plots to establish crop nutrient requirements. By removing the N, P, K and Zn from each plot individually, the impact of each nutrient on building yield can be better determined.

Table 1. Field trial in 2005, Lishi Town, Shayang county, Hubei, China.
Hybrid middle rice, variety: II you 838.

Treatments	N-P2O5-K2O-Zn	Yield (kg/ha)	%
OPT (soil test optimized)	180-90-150-5.25	7566	100
OPT-Zn	180-90-150-0	7254	95.9
OPT-N	0-90-150-5.25	5540	73.2
OPT-P	180-0-150-5.25	7104	93.9
OPT-K	180-90-0-5.25	7079	93.6
CK	0-0-0-0	5240	69.3
Farmer practice	195-66-42-0	6435	85.1

Table 2. Field demonstration in 2006, Dajin Town, Wuxue county, Hubei, China.
Hybrid late rice, variety: E Geng 17.

Treatments	N-P2O5-K2O	Disease infected %	Blighted grain %	Yield (kg/ha)	%
Soil test Rec	165-60-105	17.9	22.5	8751	100
CK	165-60	39.4	24.6	7044	81
Farmer practice	210-30-60	70.2	28.4	7677	88

Staff with IPNI have been using a common extractant for soil testing, developed by ASI Labs in Florida (Portch and Hunter, 2002). While the soil testing method may be challenged, the process of collecting and analyzing soils to help in developing local fertilizer recommendations cannot.

In India, IPNI staff have used the ASI soil sampling method to establish the soil nutrient levels, and help guide fertilizer application in research trials focused on the theme of Site Specific Nutrient Management (SSNM). With the soil analysis results the staff scientists match this with the nutrient requirements of the set yield goal. If for example, soil test P is low, then fertilizer P would be added at a rate 20% above the fertilizer requirement of the crop. This application rate would change, and be at the recommended rate based on nutrient removal of the yield goal if the soil tested in the sufficient range, and at 20% lower then the recommended rate if the soil tested in the high range (above that considered sufficient). As you can see, the goal of their recommendations is to maintain soil fertility and not cause unnecessary draw down or accumulation of nutrients.

Below are examples of wheat responses to nutrient applications based on SSNM soil testing in Meerut and on-farm trials in Karnataka (Tables 3 and 4).

Table 3. Project Directorate for Cropping System Research experimental station, Modipuram, Meerut, India. 2002-2003 Rice yields.

Treatment	**Grain Yield (t ha^{-1})**
SSNM (N_{170} $P2O5_{30}$ $K2O_{120}$ S_{20} Zn_7 Mg_{17} $B_{0.6}$)	9.95
SSNM - P	9.86
SSNM - K	9.47
SSNM - S	8.75
Local Recommendation - N_{150} $P2O5_{75}$ $K2O_{75}$ S_0 Zn_5 Mg_0 B_0	8.03
Local Soil Test Rec - N_{180} $P2O5_{55}$ $K2O_{55}$ S_0 Zn_5 Mg_0 B_0	7.94
Farmer Practice - N_{180} $P2O5_{60}$ $K2O_0$ S_0 Zn_5 Mg_0 B_0	7.29
CD *($p<0.05$)*	0.51

Table 4. Yield improvement and economic advantage in wheat (Rabi season) due to SSNM in 2005-06. Target yield was set at 4.0 t/ha. Karnataka, India.

Site No.	**N: P2O5: K2O: Zn: Fe**			Advantage in SSNM	
	SSNM 120:60:105:5:5	State Rec 100:75:50	Farmer Practice 43-100:43-57:35-85	Over SR	Over FP
	Grain yield (t/ha)			% yield increase	% yield increase
1	3.74	3.31	2.92	12.9	28.1
2	4.12	3.52	3.15	17.0	30.8
3	3.86	3.20	3.05	20.6	26.6
4	4.03	3.51	3.13	14.8	28.7
5	3.74	3.25	2.95	15.1	26.8
6	3.68	3.02	2.69	21.8	36.8
7	4.17	3.54	3.32	17.8	25.6
8	4.02	3.49	3.25	15.2	23.7
9	3.66	3.32	2.89	102.	26.6
10	3.84	3.42	3.12	12.3	23.1
Mean	**3.89**	**3.36**	**2.95**	**15.6**	**31.7**

The value of deletion plot techniques (applying the optimum rate less one of the recommended nutrients) is also shown in the winter wheat yield data from Shanxi, China (Table 5). While N and P deletion resulted in significantly lower yields than when the OPT treatment was applied, omission of K, Zn or Mn did not result in a significant yield reduction. While this may call into question the use of these nutrients on this winter wheat crop, there rates of addition are often based on crop uptake, or removal, during the growing season. There addition then becomes a matter of a local decision based on the current economics of growing the crop. In some instances the soil residual supply is more than sufficient to meet crop requirements, resulting in little agronomic or economic benefit from nutrient addition.

Table 5. BF on winter wheat yield in Linfen, Shanxi, China. (Opt = N_{180} $P2O5_{150}$ $K2O_{150}$ Zn_{15} Mn_{30}).

Treatment	Yield (kg/ha)	Relative Yield (%)
OPT (Soil Test optimized)	7724	100
OPT -N	6402	82.9
OPT -P	6481	83.9
OPT -K	7268	94.1
OPT -Zn	7353	95.2
OPT -Mn	7695	99.6

Summary

Soil testing is one of the methods by which we can assess soil nutrient status, and use this information to help in making suitable fertilizer recommendations. Balanced fertilization is our goal, and as such we should be able to use soil testing to help us identify if we have specific macro, secondary or micro-nutrient deficiencies which may limit production. The International Plant Nutrition Institute (IPNI) has been using soil testing in their programs in China and India for the past number of years, and has now accumulated a number of examples to show that while not perfect, soil testing is a powerful tool in nutrient management in Asia.

Soil testing also helps to achieve many of the goals associated with SSNM programs. In particular, soil testing helps to manage nutrients in areas of environmental concern. The promotion of BMPs for fertilizer use will depend heavily on soil testing to ensure that we are applying the right rates of nutrients, as part of the “right rate, right time and right placement” approach to fertilizer management.

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