SEASONAL VARIATION IN NITROGEN AND PHOSPHORUS IN A VERTIC CALCIXEROLL : IMPLICATIONS FOR SOIL TESTING*

J. RYAN, M. ABDEL MOMEN**, and M. EL GHAROUS

INTRODUCTION

Knowledge of a soil's fertility status - and hence that of a field or farm - is fundamental to exploring its potential through a rational program of fertilization. Soil testing as a science has advanced a long way; improvements have been made in all phases of that endeavor, i.e., from reliable sampling, through analysis and interpretation - all based on painstaking research. Soil, by its variable nature, sets a ceiling on the degree of precision and accuracy we can achieve. One aspect - seasonal changes in available soil nutrients - continues to frustrate efforts to improve on fertilizer recommendations.

While many soil nutrients may change with time (Sabbe and Marx, 1987), the possible change in available P and NO_3 are of most concern in Morocco's

* Contribution form USAID/MIAC/INRA, Project 608-0136, and Aridoculture Center, Settat, Morocco.
** Soil scientists.

dryland zone (Abdel Momen **et al.**, 1990a). However, cyclical changes with year and season are not consistently observed (Lockman and Molloy, 1986) ; apparently the magnitude and range of environmental conditions between seasons along with soil types - particularly the reserve of mineralizable organic matter - are important considerations.

The work of El Gharous et al. (1990) drew attention to the notion of mineralization of organic N in Chaouia-region soils. However, other than the observation of Ryan **et al.** (1991) that soil test values actually increased in an organic matter-rich soil (Petrocalcic Palexeroll) as the cropping season progressed, the issue of changes in soil P over time has not been considered in Morocco. Furthermore, the changes that take place with added soil have not been addressed other than indications that P does carryover to the next season (Abdel Momen **et al.,** 199b). How long will such residues persist or remain stable under field conditions in not clear. Therefore, the foregoing trial at an agricultural experiment station examined the changes in native and added P and N over a 2.5-year period.

PROCEDURE

The site for the trial was at Sidi El Aydi agricultural experiment station in Morocco's semi-arid zone (mean annual rainfall 386 mm). The soil was a Vertic Calcixeroll ; being moderately deep and with a relatively high clay content, it is characteristic of the Berrechid plain. Soils of the station and the surrounding Chaouia region have been recently described (Ryan **et al.,** 1990; Abdel Momen **et al.,** 1990c). Some relevant soil characteristics are 2.5% organic matter 440 ppm extractable K, and varying amounts of calcium carbonate throughout the profile, which extends to 60-80 cm to parent material.

The site (15 x 17.5 m) was cultivated with a disc harrow "covercrop" in fall 1988. Five unreplicated plots, four uncropped and one cropped, were laid out on Dec. 9 ; these were 15 x 3 m with 0.5 m borders or buffers. The treatments were as follows : Plot 1 = non-treated control ; Plot 2 = 80 kg P/ha as triple superphosphate ; Plot 3 = 150 kg N/ha as ammonium nitrate ; Plot 4 = 80 kg P and 150 Kg N/ha which was then planted with Saada wheat at 150 kg/ha broadcasted ; and Plot 5 = 240 kg P/ha. Both fertilizer and seed were incorporated with the "covercrop".

The plots were sampled at eight different time with roughly equal intervals over the next three years, i.e., 1989 (4), 1990 (3), and 1991 (1). The sampling procedure involved three composite samples (A, B, C) each consisting of 10 sub-samples taken to a depht of 0-20 cm and put through a 2-mm sieve for analysis. These were routinely analyzed for nitrate (NO_3) using KC1 as an extractant and chromothropic acid for color development, and available phosphorus (P) using the standard procedure for calcareous soils involving $NaHCO_3$. As K is deemed to be adequate for most soils in the dryland zone, analysis was only done on background samples. After the first year, the cropped plot (No. 4) was sampled and left uncropped, except for volunteer weeds, in the same manner as the other four plots.

RESULTS AND DISCUSSION

The data for $NaHCO_3$-P (Table 1) displayed a number of expected features. The seasonability of the test values - or rather the variation due to rainfall and its distribution - was readily apparent. While values in April 1989 and 1991 were almost identical, there was a tendency for them to increase later in the season, into the fall, and subsequently decline in winter. As no P was added to the control plot, the increase in available P had to have come from mineralized P. With increasing temperatures in spring, i.e., from a maximum low in January of about 4°C to 17°C in June, and adequate soil moisture in normal years up to April or May, soil organic matter, and therefore organic P compounds, undergo bacterial decomposition and mineral release. While this phenomenon is more pronounced for N, it also has implications for P. The decreases in P in winter are due to a resumption of biological activity which immobilizes P in the soil solution and by plant uptake - the crop or natural weeds. Given the wide fluctuation in rainfall and temperature from year to year (Watts and El Mourid, 1988), the cyclical pattern of P fluctuation would vary accordingly.

Through a well recognized aspect of soil science literature (Lockman and Molloy 1986 ; Sabbe and Marx, 1987), little reference has been made to temporal variation in test values in Moroccan soil fertility research. However, Abdel Momen and Ryan (1990) attributed the disappearance of apparent P deficiency as the growth season of wheat progress to increased P availability due to P mineralization. A following study (Ryan **et al.,** 1991) at the same site indicated that P in unfertilized plots increased from 4.8 ppm in January to 7.1 in June.

The second aspect of interest, i.e., enrichment of soil P due to fertilization and slow reversion to less available forms over time, has also been evident from data in Table 1. While higher levels of P accumulated with the higher P rate (240 kg/ha) compared to the "normal" one (80 kg/ha), both followed the same reversal pattern with time, with some obvious exceptions. While such rates vary with soils and environmental conditions (Ryan **et al.,** 1985; Matar, 1990), it would thus appear from such trends that even modest dressings of P would have an impact on the second and possibly subsequent years. However applications would persist much longer.

Another interesting feature of the data was the relatively higher level of $NaHCO_3$-P with the N treatment alone by comparison with the control and also the higher levels in the cropped P-fertilized plot in comparison with the P-fertilized but uncropped plot at the same P application rate. The only possible explanation is that the added N had a priming effect on organic matter decomposition through enhanced bacterial activity. In the cropped plot, the increased root biomass may have also contributed to the pool of mineralizable soil P.

The NO_3-N data (Table 2) were in many respects dissimilar to the P data. A common feature, however, was the cyclical pattern with the season; though this was not consistent. While a flush of NO_3 is normally expected with the onset of fall rains which stimulate mineralization, this was only observed in 1990. A possible explanation is that the Oct. sampling in 1989 occurred before any significant rains. In contrast to the influence of N on P availability, the addition of P seemed to have no effect on N mineralization.

A major contributing factor to the ephemerality of the NO_3 data was the limitation on depht of sampling; mineralized N may be easily flushed out of the 0-20 cm zone sample. The fact that plots treated with N (No. 3, 4) only showed, on average, slightly higher levels of NO_3, i. e., 13.1 and 10.5 ppm, respectively, compared to 9.1 for the control, clearly shows that much of the added N was in the profile and beneath the sampled top layer.

Table 1 : **Absolute (ppm) and relative percent changes (in parenthesis) in available P whith treatment and time.**

Plot Treatment No	1989				1990			1991
	Mar	**Apr.**	**June**	**Oct.**	**Jan.**	**June**	**Oct.**	**Apr.**
1 Control	13.4	12.8	23.5	22.5	14.9	21.9	17.5	12.7
	-	-	-	-	-	-	-	-
2 P=80 kg/ha	60.0	42.7	44.0	41.5	36.1	37.7	31.5	22.6
	(348)	(234)	(87)	(86)	(14.3)	(6.5)	(8.0)	(7.8)
3 N=150 kg/ha	22.0	17.6	26.5	25.0	18.0	27.1	22.3	13.9
	(64)	(37)	(13)	(12)	(21)	(18)	(27)	(15)
4 Cropped								
first yr.	-	-	113.0	62.0	41.0	39.9	36.3	16.3
P=80kg/ha	-	-	(381)	(178)	(175)	(74)	(107)	(28)
N=150								
5 P=240kg/ha	268	161.3	183.3	157.0	74.2	38.1	63.5	32.6
	(1900)	(1160)	(780)	(604)	(398)	(66)	(263)	(151)

Values are means of three composite samples, each of 10 sub-samples.

Table 2 : **Fluctuations in soil nitrate -N (pm) with treatments and time**

Plot Treatment No			1989				1990		1991
	Mar	**Apr.**	**June**	**Oct.**	**Jan.**	**June**	**Oct.**	**Apr.**	
1 Control	8.8	4.5	5.3	5.9	7.8	17.1	28.2	3.1	9.1
2 P=80kg/ha	4.4	3.0	5.6	6.2	11.6	17.8	25.5	2.1	9.5
3 N=150 kg/ha	10.0	4.3	5.2	7.7	11.3	23.9	39.8	2.4	13.1
Cropped first yr.									
4 P=80kg/ha	-	-	5.0	6.8	5.2	17.6	27.5	1.1	10.5
N=150kg/ha									
5 P=240kg/ha	6.6	4.3	5.5	6.0	9.4	17.2	27.3	0.6	9.6
Mean	7.5	4.0	5.3	6.5	9.1	18.7	29.7	1.9	

Thus, while the importance of N mineralization is widely appreciated, especially for dryland soils which are relatively rich in organic matter (El Gharous et al., 1990), it can only be reliably detected in the field by deeper sampling of the profile; Soltanpour et al. (1989) suggested a minimum of 60 cm - even deeper samples are taken in irrigated areas. Desirable as this may be, sampling to the sub-soil is not feasible or practical for most farmers or indeed researchers who have to resort to the use of power driven soil probes. In contrast to humid regions, soils of Morocco's dryland zone are difficult to sample manually. The typical clay soil has concrete - like consistence after months of the compacting influence of grazing animals and the baking effect of the summer sun.

SAMPLING IMPLICATIONS

Despite some seasonal change in available P, the approach to sampling the top 20 or 30 cm is a reliable one. Research in the Middle East region (Ryan and Matar, 1990) and elsewhere have unequivocally demonstrated a consistent relationship between available P in this layer and crop response. Though P levels may rise after fall rains, sampling in Sept.-Oct. is probably the most practical approach to fertilization of fall - and spring-planted crops.

Sampling for NO_3 as a basis for N fertilization is as tenuous as ever and, given the practical limitations on sampling, will probably continue to be. Soil mobility of NO_3 in response to soil moisture regimes and susceptibility to change with mineralization will always limit the value of an instantaneous field measurement to indicate N availability. As this phenomenon is environmentally controlled, our ability to predict mineralization is limited by our ability to predict the wheater in any given season.

RESUME

L'activité des micro-organismes présents dans le sol est en relation directe avec les conditions climatiques qui règnent. Un changement dans les conditions climatiques du sol (humidité et température) cause un changement dans l'activité microbienne qui affecte le processus de minéralisation - immobilisation et par là un changement dans certains résultats d'analyse du sol.

L'objectif de cette étude était de voir les variations de P. extrait par la méthode Olsen ($NaHCO_3$-P). et des nitrates (NO_3-N) dans un calcimagnésique à caractère vertique de la station expérimentale de Sidi El Aydi pour une période de 2 ans et demi. Le phosphore dans les premiers 20 cm de profondeur des parcelles témoins avait une tendance de varier d'une saison à l'autre. Alors que dans les parcelles fertilisées, ces variations n'étaient pas accentuées. Concernant les nitrates, malgré leur variation saisonnière accentuée, la majorité de N appliqué n'était pas détectée dans les premiers 20 cm de profondeur. Cependant, il est nécessaire de considérer ces limitations dans l'échantillonnage du sol pour l'analyse de l'azote.

ABSTRACT

The soil is not a static system, as environmental conditions change throughout the year, some soil test values may also change due to a complex mineralization-mobilization process. This study of a Vertic Calcixeroll at Sidi El aydi agricultural experiment station examined changes in $NaHCO_3$-extractable phosphorus (P) and nitrate (NO_3-N) over a 2.5 year-period in mainly uncropped plots. Surface (0-20 cm) sampling detected some seasonal changes in P from unfertilized samples, while fertilizer-enriched samples decreased with time. While varying seasonally, sampling did not detect most of the added N, which in the sub-oil. These limitations have to be identified in soil sampling strategies.

Key Words : Nitrate mobility, Mineralization, Soil sampling.

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