SAP TESTS FOR MEASURING NITROGEN STATUS OF CEREALS

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ABSTRACT

The possible role of sap tests for nitrate to monitor the nitrogen status of wheat and barley as part of a flexible nitrogen policy is discussed. The method is briefly described as are its main advantages and limitations.

Some preliminary results are presented that show sap tests taken at G.S. 6 were related to final yield levels. Further work to evaluate and calibrate the test is required.

Additional Key Words: wheat, barley, nitrogen fertiliser, grain yield.

INTRODUCTION

It is well known that the response by crops to nitrogen fertiliser is variable. With improved knowledge of the factors which influence nitrogen response (Stephen, 1980) and the introduction of improved soil tests (Quin *et al.*, 1982), it is possible to nominate the situations when fertiliser N is likely to be worthwhile. These methods still require some prediction of plant requirement and N availability both of which are affected by largely uncontrollable variables such as temperature and rainfall. For example, periods of waterlogging on heavy soils may temporarily reduce nitrogen availability to the plant and this may be serious if it occurs at a critical time.

Nitrate sap tests which directly and immediately measure the nitrate status of the plant provide an objective measure to indicate whether N fertiliser additional to the basal dressing is likely to be required. The test provides the means for a more flexible N fertiliser policy. Farmers could apply a normal rate of N at sowing and, with monitoring of the crop during growth stage (G.S.) 4-7, apply additional N only if required. This will improve N efficiency making the use of higher N fertiliser rates profitable by reducing the chances of nil or negative responses. Withers and Pringle (1981) indicated that potential exists on some farms for increasing N fertiliser use. If these situations can be identified during growth, use of these higher rates may be justified.

Sap tests would not entirely substitute for soil or herbage tests as they measure a different aspect of nitrogen use and should complement them.

The purpose of this paper is to discuss the possible role of nitrate sap tests in cereal growing and to present some preliminary data which would indicate that the test can be used to demonstrate the responsiveness of plants to N fertiliser. It is hoped that agronomists associated with the growing of wheat and barley will give the test serious consideration and attempt to test it, ultimately leading to a full evaluation and possible adoption by cereal farmers.

REVIEW OF SAP TEST METHOD

Use of sap tests for nitrate is not new (Williams, 1969). Early tests however involved the use of solutions containing sulphuric acid and were not convenient or safe for general field use. The commercial availability of strips for testing the nitrate content of water has meant that widespread testing of plant sap for a range of agricultural and horticultural crops is now possible.

Two general reviews of the method have been made by Scaife (1979) and Cornforth (1980). The sap test directly measures the concentration of nitrate in the plant sap and its usefulness depends on a relationship between plant nitrate and growth rate (Scaife and Baines, 1977) or yield (e.g. Papastylianou and Puckridge, 1981). In contrast to herbage tests which measure the total amount of nutrient in the plant sample, sap tests measure only the nutrient content in the plant sap and so reflects the current status of nitrogen utilisation without being influenced by storage and structural materials (Scaife and Bray, 1977). When uptake of nitrate exceeds utilisation, nitrate tends to accumulate in the stem and sap nitrate concentrations rise. Conversely if nitrate supply is below requirements then sap nitrate concentration falls.

The commercial test consists of a small plastic strip with a piece of filter paper containing the test chemical glued on one end. When the paper is wetted with the test solution (sap in this case) the filter paper changes colour to various intensities of mauve according to the nitrate concentration. In the present commercial strips, the maximum concentration measured is 500 ppm. However, in most plants, the sap concentration is much higher than this so the time taken to reach the 500 ppm colour (which is related to concentration — Table 1) is taken.

When wheat or barley is being tested, the white tiller base is sampled (Scaife, 1979). Plants are dug up, the tiller base is cut with scissors and a drop of sap is squeezed onto the test paper. The time taken for a change to the 500 ppm standard is taken.

TABLE 1: Relationship between the time taken to reach the 500 ppm standard (secs) and nitrate concentration (ppm). From Scaife (1979).

Time (Secs)	Concentration (ppm NO_3)
5	20,000
7.5	9,000
10	7,000
15	4,000
20	3,000
30	2,000
45	1,250
60	900

The level of nitrate required is still subject to calibration. Scaife (1979) states that sap nitrate concentration should rise to 4000 ppm (15 sec) during rapid early growth but after that nitrate levels decline steadily until maturity. Other important factors influencing nitrate levels are the sample position on the plant and the amount of sunlight because the latter influences the demand for nitrate.

Thus, provided the sampling position is constant, the test made under standard conditions (reasonably bright days between 10 a.m. and 4 p.m. — Scaife, 1979) and the results interpreted according to the stage of growth, then the sap test appears to reflect the current nitrogen status of the plant.

The reaction of the plant to nitrogen status is to alter growth rate so the relationship with yield would depend on the influence of the current growth rate on yield. Scaife and Baines (1977) report a positive correlation between the yield of barley and nitrate levels at intermediate stages of growth but poor correlation at early or late stages of growth.

EVALUATING THE TEST

In the 1981/82 season, sap tests were undertaken on trials established to determine nitrogen response curves of wheat and barley. The sap test sample numbers and times were limited and the experiments were not designed to examine the reliability of the test so the results must be regarded only as an initial evaluation.

Barley

Three trials were established on adjacent areas sown in barley for the previous four years, although the history of N fertiliser application at each site was different. One site received no N fertiliser with the barley (low N), one received 100 kg N/ha/yr (medium N) and a high N site received 200 kg N/ha/yr as part of a long term nitrogen fertiliser study.

The trials were sited on Tokomaru silt loam on the DSIR Tiritea Research Area near Massey University. The trials were sown on 4 and 5 November 1981 with 150 kg/ha barley (cv. Georgie) in 3 x 15 plots. After sowing, urea at a range of rates between 10 and 200 kg N/ha were applied and lightly harrowed in. Nitrate sap tests were made as earlier described on 4 December (G.S. 6) and 24 December (G.S. 9). Harvesting of 10 m x 1.3 m areas of each plot by a plot harvester was carried out on 22 February 1982.

The maximum yield on each site was approximately 4 t/ha (Fig. 1). The rate of N fertiliser at which maximum yield occurred varied between 40 and 60 kg N/ha (vertical lines, Fig. 1). This 'optimum' point on the response curve occurred consistently at the 15-20 second point on the sap

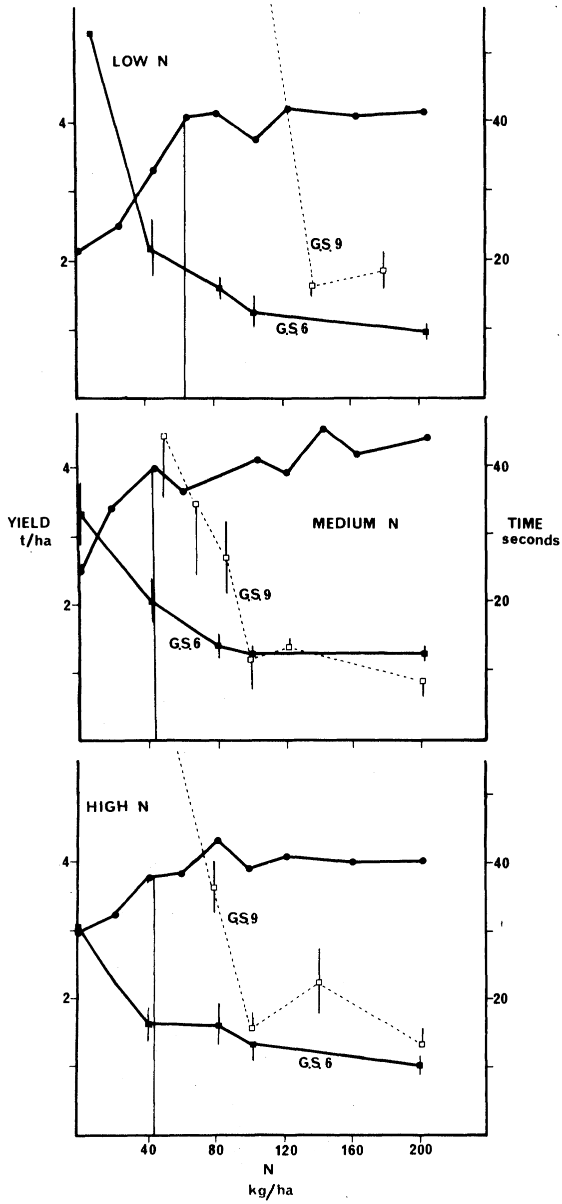

Figure 1: Grain yield (●) and sap test times at G.S. 6 (■) and G.S. 9 (□) for the barley trials.

test curve for the readings at G.S. 6 in all three trials. This level approximates the generally regarded critical level for rapidly growing crops (Scaife, 1979). The relationship between yield and sap test levels at G.S. 9 was poor.

Wheat

Trials examining rates of nitrogen ranging from 0-80 kg N/ha *in addition* to the rate applied by the farmer at sowing were laid down in 4 wheat paddocks (cv. Rongotea) in the Kairanga district near Palmerston North. The additional N treatments were applied at G.S. 2 as surface-applied urea. Sap tests and herbage samples were taken at G.S. 6 and yields were obtained by plot header from 12 x 1.3 m areas from each plot.

Only one trial responded to the additional N and data from this trial is compared with that from one of the unresponsive trials in Table 2. The sap test levels correlated well with herbage taken at the same time and with the trends in final yield.

TABLE 2: Sap test reading, concentration of N in herbage samples and final yield for two wheat trials.

Additional N (kg/ha)	Sap test (secs)	Herbage N (%)	Yield (kg/ha)
Site 1			
0	25	2.9	5230 A
40	7	3.8	5790 B
80	5	4.0	5980 B
Site 2			
0	9	4.9	4931 A
40	7	4.4	5244 A
80	4	4.7	4934 A

DISCUSSION

The sap test has interesting possibilities as a cheap and convenient method for farmers and their advisors to monitor crop N levels. It has several advantages over existing methods in that it gives immediate readings of current N status and does not require expensive laboratory and sampling facilities.

The data presented here is only an indication that the method may be effective in cereals. They show a relationship between grain yield and the plant N status at G.S. 6 as indicated by the sap test. There is a need to show whether N applied at various sap test levels at a range of growth stages will result in yield increases i.e. test its effectiveness as a predictive tool.

Variation in test readings between plants over small distances can be quite high especially when N availability become marginal. Variability is much less when soil N status is either high or low. This aspect perhaps should be taken into account as well as mean levels when assessing critical plant status. The variability pattern makes it difficult to recommend a precise number of tests that should be taken at any particular site. I have found it best to adjust the number according to how variable the readings are and how variable the paddock is in terms of topography and soil type. Relatively few tests (5-8) may be necessary on an even paddock of high or low N status but 20 or more may be necessary for variable paddocks of marginal N status.

The tests sensitivity to short term fluctuations in N supply or crop demand may be its greatest disadvantage. However, it does make the test a useful tool to monitor these trends in a crop especially over the critical growth periods. The test is probably best used as part of a regular monitoring programme rather than as a 'once only' test so that trends in nitrate levels can be evaluated in conjunction with changes in environmental conditions.

The need to time the colour change is another disadvantage although, with experience, the rate of colour change can be used as a approximate guide.

At a cost of about $18 a tube of 50 strips, the test may be regarded as being expensive if regular monitoring of a number of paddocks is to be undertaken. This cost can be minimised by careful placing of the sap at the edges or corner of the paper. In this way up to 4 tests can be obtained from one strip.

It is hoped that personnel associated with the use of N on cereals will evaluate the test under a wider range of conditions as possible. Further evaluation work at Massey University is being undertaken.

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