DEVELOPMENT OF RESEARCH PROCEDURES FOR AGRONOMIC RESEARCH AND PLANNING

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ABSTRACT

Many agronomic research procedures rely solely on economic or harvested yeild as means of evaluating crops without any attempt to understand the result. An explanation of the processes underlying crop growth is important if agronomic understanding is to advance. This will require that much greater attention be paid to the influence of environmental factors on crop growth. It is suggested that advances will be made if agronomists endeavour to link crop phenology to environmental factors. The concept of a minimum set of data on crop, soil, and climatic factors which should be collected in all trials is discussed. Ideas on the assessment of new crops are mentioned.

In all cases, agronomists should aim to clarify plant responses by linking these to soil and climatic measurements.

INTRODUCTION

Agronomists require information on environmental factors for three reasons:

(1) To identify the parameters which determine the behaviour of the plants under study in an agronomic trial.

(2) To indicate the performance of specific crops for locations where agronomic information is lacking.

(3) To match new plant cultivars and species to particular environments.

In the past, environmental data have often been collected during trials but they have been used relatively infrequently to aid trial interpretation. Several government and non-government agencies were concerned at this trend and after discussions between Ministry of Agriculture and Soil Bureau, DSIR, a Working Party was established to examine this question. The Working Party was asked to report its findings to the Agricultural Research Division, Ministry of Agriculture and Fisheries.

The Working Party first met in November 1979. It comprised personnel from Ministry of Agriculture, Soil Bureau and Plant Physiology Divisions of DSIR, the New Zealand Meteorological Service, and the Ministry of Works and Development. Its brief was to report on three main topics:

(1) To outline minimum information required to describe adequately the environment in a way which is meaningful to agronomic trials.

(2) To indicate the best methods to monitor the environmental parameters recommended.

(3) To indicate how the environmental information collected can be organised to assist in the interpretation of agronomic trials.

The objective of this paper is to outline some fo the ideas which have been considered by the Working Party and which will be discussed in its report.

CURRENT PRACTICES

Gandar and Kerr (1980) discuss some of the deficiencies in current agronomic research. In many trials, environment-plant relationships are not measured quantitatively and, as a result, are inadequately understood. Detailed studies will be required to unravel these relationships. Unless this research is done it will be difficult to solve many agronomic problems. However, we should beware that this single factor approach of in-depth work does not lead to a series of isolated disconnected papers and so lead into the scientific junk yard.

Agronomists must also consider the context of their research. Snaydon (1979) has highlighted the large discrepancies that arise between experimental and farm performance in Britain, pointing out that the ultimate criterion for selecting species and cultivars is profitability under realistic farm conditions. He also points out that an unjustifiably large amount of attention has been devoted to the choice of species and cultivars when they only account for 5% of the variation of farm output; the other 95% being environment and management. He makes a strong plea for more effort in defining the climatic, soil and management factors which largely determine crop and animal output and profitability. This is a sentiment which is appropriate to New Zealand conditions.

DEVELOPMENT OF RESEARCH PROCEDURES

Agronomists should be encouraged to make more use of environmental inputs both to increase their understanding of crop-environment relations and to increase the applicability of trial results. The following are some areas in which research procedures could be developed.

1. Phenology

Phenology is that branch of science concerned with the relations between climate and periodic biological phenomena. It includes a study of the relationship between physical factors in the environment and seasonal changes in the growth and development during the life cycle of plants and animals (McCloud *et.al.*, 1964).

Agronomists should be encouraged to describe the phenology of the crop being studied as the first step toward a more detailed explanation of plant performance, adaptation and commercial success. Such an approach has an increasing number of advocates but little publicity in New Zealand. The main proponents in the past have been agricultural scientists involved with irrigation (e.g. Dougherty, 1972; Rickard, 1973; Kerr and Clothier, 1975).

Examples of phenological keys are given in "Crop Loss Assessment Methods" (Chiarappa, 1971), in "Guidelines for Field Evaluation of Herbicides" (Department of Primary Industry, 1979) and in the decimal growth stage key proposed by Zadoks *et.al.* (1974) for cereals. Crop tolerance and disease keys are less well documented but some visual methods of scoring are outlined in the papers quoted. Keys for fungal and bacterial diseases have also been described by Dixon and Doodson (1971).

2. Minimum Data Sets

It is clear from Gandar and Kerr's (1980) analysis of agronomic papers that many of the environmental data required for the interpretation of the results are missing. There is a need for research agronomists to collect a balanced data set in experiments. This approach has been advocated by Nix (pers. comm.) in Australia. He proposes that minimum sets of data on crops, soils, and climatic factors be collected in agronomic trials. He divides trials into three levels and suggests an appropriate minimum data set (MDS) for each.

Level 1: Absolute minimum requirements for relating crop performance to environment and for comparative analysis of crop performance at widely spaced sites, at many sites, or over many seasons. Rainfall must be measured at the site but other weather and climatic data can be obtained from a meteorological station within the general locality. This level is generally applicable to field trials remote from experimental stations. (e.g. A simple soil water budget can be constructed with the meteorological data and related to the crop growth stages). Visits would be monthly or less frequent. The data are adequate for calculation of simple biophysical indices and for verification of the most general prediction models.

Level 2: Recommended as the minimum requirement for all experiments conducted at regional research stations. More comprehensive weather, soil and crop physiological data are collected to permit a closer analysis of crop performance on a physiological or process basis, and of major environmental constraints. (e.g. Soil water would be measured weekly allowing for the testing of models relating to crop growth, development and yield.) Visits more frequent than monthly.

Level 3: The sophistication of data collection will be superior to that of level 2 and would specify the minimum requirement for all "in-depth" work relating to plant growth. Data collection would be restricted to regional research stations or research areas and accumulated very often by means of data loggers. (e.g. Soil water in this cause would be monitored continuously by tensiometers or neutron probes to verify the computed water budget and to enable this to be used as a tool for the interpretation of crop growth, development and yield.) Visits at least weekly, and possibly daily. The aim at this stage is to synthesize all the components studied so that predictive models of crop growth and development are available for general use.

In this hierarchy it is recognised that experiments have different functions (ranging from primarily "demonstration" trials to elaborate experiments examining "in-depth" various crop x environment and crop x management interactions) and that the scale of facilities for experimental work varies. The aim of the hierarchal MDS concept is to increase the range precision, accuracy, and frequency of data collection, while maintaining a balanced monitoring of the whole crop system. At all levels of this hierarchy the emphasis is on the minimum set of data required for explanation of crop performance at that level.

Tables 1,2 and 3 illustrate how some of the various crop, weather and soil parameters are successively included as the experiments are placed further up the hierarchy.

TABLE 1: Crop growth measurements.

	Each minimum data set used includes all lower levels.	Minimum Data Set Level
1.	Economic or harvested yield	1
2.	Crop habit, Leaf stem, petiole, roots; evenness of ripening.	1
3.	Effect of grazing on crop recovery and yield, type of stock, palatability	1
4.	Lodging score	1
5.	Diseases (seeds, grains, pods, leaves)	1
6.	Shattering	1
7.	Sprout	1
8.	Straggling	1
9	Yield and species components	2
10.	Plant population (per m^2) at establishment and harvest	2
11.	Weight of clean harvested grain or seeds — (seed weight)	2
12.	Quality tests	2
13.	Border effects	2
14.	Canopy height and leaf area index at various growth stages	3

TABLE 2: Weather

		Minimum Data Set Level
1.	Rainfall	1
2.	Soil temperature and air temperature from local meteorological station	1
3.	Soil and air temperatures (measured on-site)	2
4.	Solar radiation (measured on site)	2
5.	Pan evaporation (measured on site)	2
6.	Wind run and direction	2
7.	Maximum evapotranspiration (estimated)	2
8.	Actual evapotranspiration (measured)	3
9.	Diurnal leaf, air, and soil temperatures (measured)	3
10.	Wind profiles (measured)	3

TABLE 3: Soil Physics

		Minimum Data Set Level
1.	Soil type	1
2.	Water table depth	1
3.	Texture profiles (with exact depths of discontinuities)	2
4.	Total and macroporosity	2
5.	Bulk density through profile	2
6.	Field capacity, wilting point. Available soil moisture.	2
7.	Soil particle specific gravity	2
8.	Soil moisture tension curve	3
9.	Infiltration curves	3
10.	Hydraulic conductivity	3
11.	Available water content within soil profile layers.	3
12.	Seed bed soil structure (bulk density, penetrability, structural stability)	3

3. **Testing New Crops**

The testing of established crops poses no particular problem as the performance of these will be known by tradition, experience and experiment. Quantitative performance data may be lacking or only qualitatively described, so that, for many species agronomists still have the task of sorting out growth-environmental relationships.

The testing of new crops poses different problems and definite research procedures must be established. The general niche that the crop occupies in its native biotic zone can be determined, and potential new regions identified using historical climatic data. Experimental sites within the limits of the crop's environmental range should be included as part of any assessment programme. The rainfall pattern of most districts is known. Simple phenological observations of the new crop will help to determine whether it is suited to the test locality. Responses to temperature and radiation should be measured from the start of the evaluation in the absence of moisture stress. An irrigated treatment should, therefore, also be included to avoid the risk of drought; this automatically provides a low moisture stress treatment and cuts down on the number of seasons required for crop assessments.

These procedures will enable agronomists to answer the questions about new crops posed in the Introduction. More detailed experimental procedures will be required if a new crop becomes established and assessments of fertiliser needs etc. become necessary.

CONCLUSIONS

Agronomists must measure parameters which more adquately describe the behaviour of crops in the field within a specific environment or among a range of environments. The range of measurements completed in any agronomic trial needs to be kept in balance so that the crop, soil and climatic information recorded can be used to explain the crop's performance and final yield. It is realised that it is not appropriate to record the same intensity of information in all agronomic trials. Therefore, three levels of minimum data sets are proposed — the responsibility of the experimenter is to select the appropriate set.

The ideas put forward in the symposium are for discussion and evaluation by the practising agronomists. They form part of the procedures being used by the Working Party in the preparation of its report for the Ministry of Agriculture and Fisheries.

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