NUTRIENT THREAT TO SUSTAINABLE AGRICULTURE

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Summary. A major problem of the next century will be to grow enough food on declining arable land to feed the increasing world population. Despite excellent research in Australia on many aspects of crop growth, yields have not increased greatly and protein levels of wheat have fallen.

An essential issue in the future is to concentrate on the soil nutrient capital base and relate it to the nutrient inputs and outputs from different systems in order to give maximum yields per unit of water use. Increased food costs will be necessary to help farmers replace the nutrients.

INTRODUCTION

World population is increasing by about 90 million per year (3), but the area of arable land is being reduced by about 10 million hectares per year and serious doubts are being raised about the ability to provide adequate food for the world population by the year 2020.

Land is going out of production due to urban and industrial expansion around cities with reasonable rainfall and fertile soils. In Australia, in the 1980's, about 140,000 hectares were lost each year due to this expansion (2). Other land is lost by degradation and erosion. Droughts will also reduce food supply and estimates suggest that, world wide, the main cereal crops - rice, maize and wheat - will require a 70% increase in production by the year 2020.

Australia currently produces enough food for itself, and exports sufficient amounts to help balance the cost of imports. This year, the value of our export-oriented agriculture will be about $18 billion out of the total value of $50 billion in exports - most of the difference coming from mining and machinery exports.

Hamblin and Kyneur (4) have shown that wheat yields throughout Australia increased only slightly between 1950 and 1990. The average increase was 8 kg/ha/year - although the figure reaches 20 kg/ha/year in a few districts. Most yields are only about 40% of the potential yield, based on water use efficiency. Also grain protein values of wheat are declining; this is linked to declining soil organic matter.

Sustainable agriculture is a major concern on our drier fragile soils and future research must involve the interaction of the most important factors involved in integrated farming systems. This paper deals with the cereal-pasture systems in mid to southern Australia which contribute about 35% of Australia's agricultural production.

CURRENT YIELD LIMITATIONS

(a) Visible factors: These include erosion and soil structure decline due to excessive tillage, salinity impacts, consequences of stubble burning, weeds and in particular herbicide resistant weeds, low plant density, discolouration in leaves, deterioration in legume based pastures, crop varieties and different soil types. Other occasional unexpected factors include locust and mouse plagues and summer weeds.

(b) Hidden factors: These include the depth of the soil profile, the variation in texture and bulk density which can influence waterlogging, root development and root disease (6), the level of sodicity, acidity and toxicity of elements such as boron and aluminium, earthworm numbers and the amount and variety of soil micro-organisms. A major determinant of yield, however, is the range of nutrients needed by plants, and the amount of each nutrient readily available to plant roots in the soil profile.

While some farmers can adapt their management to include research that increases yield, many are still confused because of the overload of information and the uncertainty of whether it will prove profitable in their climate, soils and rotations. This can only be overcome with greater education of farmers and through the use of private industry and government consultants.

Farmers terms of trade have declined from an index of 220 in 1961 to 100 in 1991, and if farmers can't make a profitable livelihood, they are not able to restore degraded land. Farmers are looking for indicators to measure the impacts of their farming practices on their soils. A number of these indicators are already being used, eg. yield as a percentage of the potential yield for the water used, trends in the soil organic carbon levels, available phosphorus levels, grain protein, wool production per head and per hectare, milk production and net income per hectare. Not all factors can be discussed in a paper of this length so we will concentrate on the nutrient balance sheet for high production.

ASSESSMENT OF NUTRIENT NEEDS

Analyses of various nutrients in soils and plants have been carried out for many years as a guide for fertilizer needs. These include: (i) soil test eg. Colwell extractable phosphorus (P) - adequate with 30-45 mg/kg soil depending on soil type, total and available nitrogen, pH, salinity. (ii) plant tissue tests from samples taken at various stages and parts of plants eg. cereals - youngest emerged blade (YEB) - adequate nutrient levels are nitrogen (N) 5.5% and phosphorus (P) 0.44% at growth stage 3; medics - youngest open leaf blade (YOL) - adequate P 0.38%.

While these analyses can indicate the shortage of specific nutrients, successful growth of crops and pastures requires a range of nutrients which are available for uptake by roots and in a balance with each other. Phosphorus is especially important as it is the dominant nutrient to provide energy for the uptake of other nutrients. An inadequate supply of any other nutrient creates an imbalance which will limit the ability of plants to utilise other nutrients and reduce the potential yield for the amount of water available. Other interactions with nutrients are: Take-All damage in cereals is increased by manganese and P deficiency, rhizoctonia root rot is increased by low zinc and N nutrition, earthworm numbers are increased by the improved P nutrition of pastures (6).

It is for these reasons that farmers need to know the amounts of many nutrients in the whole top growth of crops at different stages of growth.

NUTRIENTS IN CROPS

Data in Table 1 show the nutrient uptake in the whole plant of wheat, lupins and canola and a medic pasture at 2 tonne per hectare (t/ha) dry weight (A), and at harvest (B). Compared with wheat in the early growth, the medic pasture needs higher uptakes of N, P and calcium, the canola needs higher sulphur, calcium and zinc while lupins need higher calcium and manganese. While the figures for the harvest may vary somewhat due to varieties, soil type and climate, they do relate to high yield crops. They therefore can be used as indices for farmers to check the efficiency of growth in their individual paddocks. A key issue is that the phosphorus uptake at the early growth stage for wheat should be 2 kg/ha per 25 mm water use. The uptake of other nutrients can then be expressed as a ratio to phosphorus and any deficiencies identified. Calculations can also be made of the harvested yield (kg/ha) per millimetre of water use.

Table (1B) also shows the nutrients present in the crops at harvest. The nutrients in the grain will be removed and the losses of nitrogen and phosphorus range from 64-84% of the total uptake in different crops. Calculations can be made for the other nutrients. The fate of the straw, whether baled and removed, burnt, or ploughed in - will also impact on the soil nutrient base, earthworm and biology activity. The data indicate the nutrients that need to be replaced with fertilizers to maintain a production base.

The amount of nutrients removed from cropping paddocks in southern Australia is increasing due to the greater proportion of crops in rotation. As well, an increase in the amount of calcium removed from the

paddock in grain legumes and in hay from medic pastures will lead to greater acidity. In the Mid-North of S.A., the rotations used to be fallow- wheat - pasture. However, recent surveys show that cereals (wheat, barley, oats) occupy 51% of the farming land, grain legumes (peas, faba beans, lupins) 29%, fallow 2% and pasture 18% - of which only 3% are legume dominant and 15% consist of volunteer grasses, weeds and some legumes.

Table 1. Nutrient uptake in: A- the first 2 tonnes per hectare of the whole plant and B- at harvest.

	A				B						
	Wheat	Lupins	Canola	Medic Pasture	Wheat		Lupins		Canola		Medic Pasture
					Grain	Straw	Grain	Straw	Grain	Straw	Total
Dry Matter: t/ha	2.0	2.0	2.0	2.0	3.77	8.00	3.26	8.20	3.08	7.50	8.18
Nutrient Uptake:	kg/ha										
N	60	80	75	100	102	59	188	36	120	72	234
P	6	6	7	11	8	3	18	4	21	7	22
K	70	50	64	80	13	141	35	137	27	217	195
S	5	5	13	7	7	11	13	17	30	18	19
Ca	5	35	26	25	1	11	6	35	12	13	79
Mg	3	11	7	8	4	13	11	18	11	21	24
	g/ha										
Cu	22	20	26	25	31	86	18	36	24	72	82
Zn	48	75	160	95	61	43	113	68	120	43	151
Mn	105	410	68	110	177	483	57	142	81	54	229

Water Use (mm)	85	130	85	70	400	388	400	278
Evaporation (mm)	140	150	100	80	672	638	660	342

In SA, the 1993 harvest of cereal grains and grain legumes removed 170,000 tonnes of nutrients from farmer's paddocks, the major nutrients being N, K and P. The cost of the fertilizer to replace the nutrients would be about $126 million, but more would be needed to accommodate losses and fixation; for example only about 50% of the N in fertilizer is taken up by crops. In the same year, farmers spent only about $50 million on fertilizers leaving a huge gap between the amounts of nutrients supplied and the amounts removed.

The cost of replacing the nutrients in 1 tonne of wheat is $28, and the value of nutrients in the accompanying stubble is about $45. With lupins, the nutrients in 1 tonne of grain are worth $60, and in the stubble $36. The value of nutrients in 1 tonne of canola is $45 and in the stubble $75.

Further losses of nitrogen can occur through volatilisation, denitrification and leaching, and more research and monitoring is required to reduce the losses.

NUTRIENTS IN LIVESTOCK MANAGEMENT

The amounts of nutrients needed to produce good quality pasture for livestock grazing are also high. In a year, a sheep needs 25 kg N and 3 kg P while a cow needs 130 kg N and 20 kg P, along with all the other nutrients. Nutrients are removed from the paddock in animal products eg wool, meat and milk.

Nutrient losses also occur with grazing. Thus a sheep which eats 1.5 kg of feed a day takes in 42 grams of N of which 25 g are in urine and 14 g in the dung; about half of the N in the urine is lost by volatilisation (P. Hynd, pers. commun.).

Grazing patterns can also create a marked variation in nutrient distribution through the excreta. While sheep camps may occupy only about 3% of the paddock, they contain 22% of the excreta, which leads to high concentrations of N, available P, exchangeable K and calcium in parts of the paddock (5).

ORGANIC FARMING TO REPLACE NUTRIENTS

Claims are made that the best way to manage the nutrient balance problem is to change to organic farming. However, such farms depend on manure or plant residues to provide the nutrients, but these nutrients have been provided by importing feed that has been grown elsewhere with fertilizers, and the nutrients in the manures are not returned to their original location. This results in a drain of nutrients from conventional farms to organic farms.

NUTRIENT TRAIL THROUGH CITIES AND OVERSEAS

The food from farms is either exported or sent to cities and towns. The average person eats about 84 kg of bread, cake and rice, 31 kg meat (beef and lamb) and 90 kg of poultry, pork and fish meat per year. In Adelaide (population one million) the consumption of nutrients is:-
bread and cereals, 3800 t of N, 470 t P, 720 t K and meat, 2400 t of N, 110 t P, 300 t K. About 80 % of the above nutrients go to sewage works and are not returned to farms.

It has been suggested that the recycling of sewage sludge and effluent offers a solution to returning nutrients to farms. A problem is that health hazards can occur in agricultural situations with sewage due to the presence of heavy metals, pathogenic viruses and salinity.

Even if these problems could be overcome, the fact that we export around 80% of our total agricultural production means the bulk of the nutrients removed from farms go overseas. For example, the average yearly export of wheat over the last 10 years is about 12 million tonnes which represents a loss of 276,000 t of N, 36,000 t of P and 60,000 t of K. Further losses from other nutrients and crops can be calculated from Table 1. Other nutrient losses occur with the export of hay, livestock products and horticultural produce.

Sustainable agriculture cannot be maintained unless this nutrient drain from farms is restored.

FUTURE PLANS

If we are to maintain a viable and profitable agricultural system to feed future generations, we need to develop farming systems that integrate the climate, soil and biological factors to sustain production. This demand for food could increase if global warming affects the plant growth patterns in different parts of the world.

We also need to protect prime agricultural land from urban expansion, to actively define a productive nutrient base within the soils and maintain the base by recording the complete nutrient input- output data for all crops and pastures.

Farmers are not paid enough for the food they produce and are therefore not able to buy enough fertilizers to replace the nutrients removed in their farm products. Economists should put a value on the nutrient capital base and on the cost of maintaining all nutrient levels in the soil so this can be built into the returns farmers should receive for their products.

To maintain a sustainable agriculture we need to define accurately the costs to the environment, soil and water of producing food, and then support the rural community with appropriate financial assistance to cover these costs.

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