Wheat yield responses to potassic fertiliser on Canterbury arable soils

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Abstract

Wheat yield responses to factorial combinations of either four or five rates of muriate of potash, two rates of lime: ammonium nitrate and two rates of superphosphate were measured in the 1970s on 13 Canterbury sites which had been shown by soil analysis (ammonium acetate extraction) to have low concentrations of plant-available potassium. Two methods of potassic fertiliser application were tested. On all sites wheat grain yield responses to muriate of potash were small (= 0.1 t/ha) and, apart from five sites, not statistically significant ($P < 0.05$). Over all sites, mean wheat yield response to muriate of potash was not significantly affected ($P < 0.05$) by its method of application and was not correlated significantly with measured soil concentrations of plant-available potassium. Both nitrogen and phosphate applications significantly increased wheat yields at 10 of the 13 sites. The general absence of statistically significant wheat yield responses to applications of muriate of potash and the failure by the ammonium acetate extraction procedure to correctly identify sites lacking sufficient plant-available potassium for wheat growth are attributed to the presence of illitic and inter-layered hydrous mica clays in the test soils. The validity of a procedure recently proposed as a basis for advice regarding fertiliser use in arable cropping is discussed.

Additional key words: *muriate of potash, lime:ammonium nitrate, superphosphate, ammonium acetate extraction*

Introduction

Early investigations into the effects of fertilisers on wheat growth on South Island arable soils showed no response to the application of potassic fertiliser (Hudson and Woodcock, 1934; Lynch, 1956). Guidelines for wheat production (e.g., Millner and Hampton, 1986; White, Millner and Moot, 1999) state that wheat yield responses to potash on most New Zealand soils are very unlikely. However, Millner and Hampton (1986) recommended applying from 20 to 30 kg potash/ha if soil levels became very low (MAF quick test of < 3) following potash removal in the harvested grain and straw.

In the last 25 years, the role of potash in New Zealand wheat production has not been re-evaluated, and authoritative publications such as those by McLaren and Cameron (1996) and White and Hodgson (1999) lack substantial comment on the topic. This objective of this paper is to report the effects of potassic fertiliser on wheat yields at potassium deficient sites in central Canterbury. While the experiments were conducted in the 1970s, the results have not been supplanted by more recent data.

Materials and Methods

In the mid 1970s, thirteen field experiments were undertaken to measure, in the absence and in the presence of nitrogenous and phosphatic fertilisers, the effects of potassic fertiliser on wheat yield on Canterbury arable soils occurring in the central districts of Canterbury. Whenever possible the field experiments were located on sites which the available soil-testing procedure for plant-available potassium (Hogg, 1957) indicated were poorly supplied with plant-available potas-

Table 1. Details of experimental sites.

Experimental site	Locality	Soil [1]	Plant–available K [2]
1	Sumner Hill	Mairaki silt loam	13
2	Methven	Gorge silt loam	3
3	Methven	Gorge silt loam	2
4	Cairnbrae	Lynhurst stony silt loam	4
5	Irwell	Waterton shallow clay loam	3
6	Irwell	Temuka clay loam	4
7	Methven	Lynhurst silt loam	5
8	Buccleugh	Ruapuna stony silt loam	3
9	Highbank	Lyndhurst silt loam	7
10	Hororata	Ashley silt loam	6
11	Highbank	Lyndhurst silt loam	5
12	Buccleugh	Ruapuna stony silt loam	2
13	Mt Hutt	Gorge silt loam	4

[1] Kear *et al.* (1967).
[2] Ammonium acetate extraction.

sium. Details of the experimental sites and measured soil concentrations of plant-available potassium are given in Table 1.

At each experimental site machine-dressed, fungicide-treated wheat seed was drilled into a conventionally cultivated seedbed in seven-row plots, each 1.25m wide and either 30m or 40m long. Adjacent plots were separated lengthwise by a 25cm gap. The wheat cultivar Arawa (Copp and Lobb, 1956) was sown on the first four sites and Kopara (Copp, 1972) was used on later sites. Apart from the one that was sown on site 13, in early spring (September), the experimental crops were drilled either in late autumn (May) or in early winter (June). Over all sites the mean quantity of wheat seed sown was 107 ± 6 kg/ha.

Four or five rates of muriate of potash (N:P:K:S, 0:0:48:0), including a “nil” control, and two methods of potassic fertiliser application were tested. In the “drilled” method of application muriate of potash was drilled with the wheat seed, and as required, also with superphosphate. For the “broadcast” method of application muriate of potash was top-dressed onto the surface of the seedbed and lightly harrowed in before the wheat seed was drilled. Details of the quantities of muriate of potash applied and their method of application are given in Table 2.

Two rates of fertiliser nitrogen, namely a “nil” control and 97.5 kg N/ha were compared. At early tillering (Feekes G.S. 2-3) 375 kg/ha of granulated lime: ammonium nitrate (N:P:K:S, 26:0:0:) was top-dressed onto the seedbed surface of appropriate plots.

Two rates of fertiliser phosphate, namely a “nil” control and 22.5 kg P/ha were tested. At crop seeding 250 kg/ha of coarsely powdered superphosphate (N:P:K:S, 0:9:0:11) was drilled with the wheat seed, and as required, also the potassic fertiliser.

All potassic fertiliser treatments, the nitrogenous fertiliser treatments and the phosphatic fertiliser treatments were factorially combined and applied randomly to each of three replicated blocks of 16 or 20 plots.

At early wheat plant establishment (Feekes G.S. 1) the densities of wheat populations on all plots on each experimental site were visually assessed to detect germination injury. At later stages of wheat growth relevant applications of herbicide, insecticide or fungicide were made when treatment was considered desirable. None of the experimental wheat crops was irrigated.

In late summer (February) the mature experimental wheat crops (Feekes G.S. 12) were harvested plot by plot, with a small, self-cleaning header. All seven rows of each plot were taken. The mature wheat grain harvested from each plot was weighed and its moisture content measured. Raw wheat yields were corrected to standardized 15 % moisture content.

Moisture corrected wheat yield data from each experimental site were subjected to analysis of variance.

Table 2. Wheat grain yields t/ha in response to muriate of potash treatments.

Muriate of Potash		Experimental Site												
(kg/ha)	Application	1	2	3	4	5	6	7	8	9	10	11	12	13
Nil		7.8	5.1	6.0	4.4	2.7	4.7	3.1	3.3	3.8	5.0	3.9	4.1	5.7
62.5	drilled			6.0	4.4	2.6	4.8	3.1	3.6	3.7	5.3	4.1	4.4	5.7
125	drilled	7.7	5.6	6.1	4.4	2.6	4.7	3.2	3.8	3.6	5.2	4.2	4.5	5.8
125	broadcast	7.7	5.2	6.0	4.4	2.6	4.7	3.2	6.3					
250	drilled									3.7	5.0	4.1	4.5	6.0
375	broadcast	7.7	5.2	6.0	4.4	2.6	4.7	3.2	3.7	3.7	5.2	4.1	4.4	6.0
Significance		ns	**	ns	ns	ns	ns	ns	**	ns	*	**	**	ns
LSD $_{P<0.05}$		0.13	0.16	0.14	0.18	0.14	0.15	0.10	0.16	0.28	0.22	0.18	0.21	0.32
LSD $_{P<0.01}$		0.17	0.21	.019	0.23	0.18	0.19	0.14	0.21	0.37	0.30	0.24	0.28	0.43
CV (%)		2.0	3.6	2.8	4.8	6.4	3.7	3.9	5.2	9.0	5.2	5.3	5.7	6.7

Moisture corrected wheat yield data from those treatments tested on all 13 experimental sites were combined and subjected to an overall analysis of variance.

Results

The experimental wheat crops established well and the visual assessments of the densities of wheat plant populations, made at early establishment (Feekes G.S. 1), did not reveal evidence of germination injury.

At eight experimental sites wheat yields were not significantly affected (P<0.05) by any muriate of potash treatment (Table 2). On experimental sites 2, 8, 10, 11 and 12 at least one rate of muriate of potash caused a marginal but statistically significant improvement in wheat yield (Table 2). Analysis of combined wheat yield data from all 13 sites showed the overall mean improvement in wheat grain yield induced by muriate of potash was small (0.1 t/ha) but statistically significant (P<0.034). Analysis of combined wheat yield data showed the overall mean difference between yield induced by muriate of potash drilled with the wheat seed and that broadcast onto the surface of the seedbed prior to drilling the wheat seed was very small, (0.03 t/ha), and not statistically significant (P<0.391).

Application of lime:ammonium nitrate to early tillering wheat (Feekes G.S. 2-3) significantly enhanced wheat grain yields on ten experimental sites. The overall mean improvement in wheat grain yield caused by the nitrogenous fertiliser, 0.8 t/ha, was highly significant (P<0.001). Superphosphate, drilled with the wheat seed, significantly (P<0.013) improved wheat grain yield on ten experimental sites, but the overall mean increase in grain yields caused by the phosphatic fertiliser was only 0.2 t/ha.

Of the 39 two-factor interactions involving potassic, nitrogenous and phosphatic fertiliser treatments only two achieved statistical significance. On site 8, in the presence of fertiliser nitrogen, muriate of potash drilled with the wheat seed caused significantly greater increases in wheat yield than in its absence. Similarly, on site 11, when applied with superphosphate, muriate of potash drilled with the wheat seed, induced significantly larger improvements in wheat yield than in the absence of the phosphatic fertiliser.

Regression analysis of wheat grain yield responses to muriate of potash with soil concentrations of plant-available potassium gave a weak and non-significant correlation (r = -0.0297).

Discussion

The wheat yields reported may be considered low by today's standards, where a combination of higher yield potential cultivars, irrigation, higher rates of nitrogenous fertiliser and better targeted disease control can result in yields of well over 10 t/ha. However non-irrigated wheat yields of 5 – 7 t/ha are still common, and thus as the 13 trials were not irrigated, the yield response data are still relevant.

For all practical purposes, wheat yields, like those reported by Hudson and Woodcock (1934), Lynch (1956) and Cossens and Feyter (1974), were scarcely affected by applications of muriate of potash. The results of chemical analysis reported by Wright (1964) and Douglas (1982) showed grain harvested from New Zealand wheat crops not treated with potassic fertiliser contained near normal concentrations of potassium, indicating that local wheat crops obtained adequate supplies of potassium from the soil and therefore that use of potassic fertiliser in wheat cultivation is unnecessary**.** The phenomenon of a crop obtaining adequate supplies of potassium from a local soil shown by Metson and Hurst (1953) was attributed to the presence of illitic and inter-layered hydrous mica clay minerals in the soil and their capacity to recharge soil reserves of plant-available potassium from structural potassium (Fieldes, 1968; Metson, 1968a,b)**.** The recharge of soil reserves of plant-available potassium from unavailable forms not only makes the use of potassic fertiliser in arable cropping on Canterbury arable soils unnecessary but also explains the failure of the soil test, based on ammonium acetate extraction, to correctly identify potassium-deficient sites.

An important factor influencing fertiliser use in the cultivation of arable crops is farmer expectation of earning an adequate profit on monies invested in the practice**.** At the current cost of muriate of potash and the cash return currently anticipated from the sale of milling wheat an application of 125 kg/ha of muriate of potash must improve wheat grain yield by 0.23 t/ha if it is to produce a 10 percent profit**.** In the field experiments detailed here, profitable improvements in wheat grain yield were attained adequately only on sites 2, 8, 11 and 12.

The persistent occurrence of poor wheat grain yield responses to applications of potassic fertiliser challenges the current view that fertiliser use in arable cropping should be based on estimates of losses of essential plant nutrients from the soil as a consequence of the harvest of crop and/or livestock products (Morton, Craighead and Stevenson, 1998)**.** Apart from the difficulty of estimating soil losses of plant nutrients the procedure favoured by Morton *et al.* (1998) ignores the quantities of plant nutrients that become available from soil minerals and thereby leads to extravagant recommendations for applications of some fertilisers**.** Clearly the claim that advice for the fertiliser use be based on anticipated nutrient losses from soils needs to be qualified by more complete knowledge of soil characteristics than is available currently**.**

Conclusions

The comparatively limited number and small sizes of grain yield responses to muriate of potash show that the general use of potassic fertiliser in wheat growing on Canterbury arable soils is not cost effective, and unlikely to become a commercially viable practice.

Although the utility of the procedure used to determine soil concentrations of plant-available potassium has been questioned it has to be acknowledged that a soil test procedure is unlikely to perform well when evaluated with a small number of samples taken from comparatively fertile soils.

Because of the time elapsed since these field experiments were conducted, and the many subsequent changes to wheat growing practice, it may now be appropriate to reinvestigate the use of potassic fertilisers in wheat production.

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