Long-term rotation studies - the influence of clover and crop sequence on maize yields at Glen Innes

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Summary. The effects of long-term crop rotation sequences have been examined at the Agricultural Research and Advisory Station, Glen Innes for over 60 years. The inclusion of a clover phase in the rotation has proved beneficial to both productivity and sustainability of maize crops. In some clover sequences, total maize yields from fewer crops have been greater than those achieved from more crops in the non-clover rotations. In the absence of a clover phase in the sequence, the inclusion of an autumn oat crop has improved the sustainability of maize yields.

Introduction

Early farming practices on the Northern Tablelands of New South Wales consisted largely of continuous cropping, which resulted in declining crop yields (1). The New South Wales Department of Agriculture commenced a crop rotation experiment in 1921 to develop rotations which would maintain soil fertility while continuing to produce economic crops of maize and oats. The objective was to demonstrate how fertility and crop yields could be maintained without major changes to commonly used farming systems. Three crop sequences which were frequently used throughout the area and exploitative of soil fertility were selected as baseline treatments and were compared with similar rotations which included a legume phase. Red clover was selected *as* the legume because of its suitability to the district, its reputation as a 'soil-improving crop' (1) and the grazing value it provides for livestock. The effect of including red clover in the rotation has been measured by its effects on subsequent crop yields.

It has been suggested that the experiment is no longer relevant to current local practices and should be terminated. Fortunately these suggestions have been resisted because of the conviction that valuable information would be obtained such as that yielded by other similar long-term experiments in Australia (e.g., the crop/pasture experiment at the Waite Institute, 1926- (3) and the grassland plots at Kybybolite 1919- (4)).

The crop sequences have been adhered to and yields and forage production data from the experiment have been collected annually, so that there are very few gaps in these data. This paper discusses maize yield data from the five completed cycles of the experiment covering the period from 1922-1981. Data for the other crops and soil parameters will be reported elsewhere.

Methods

The experiment is located in a permanent position on a prairie soil of basaltic origin in mid-slope on a western aspect at the Agricultural Research and Advisory Station, Glen Innes. There are seven rotation sequences, three are exploitive rotations (1-3) while four rotations are aimed at maintaining fertility by the inclusion of a legume in the sequence (4-7). The addition of a legume phase naturally lengthens the crop sequence in each rotation. Since the rotations include sequences of two, three or four crops, with the number of replicates in each rotation being equal to the number of crops in the sequence, comparisons of some aspects of all rotations can only be made at the end of a 12-year cycle. Crop sequences for each rotation are listed below and crop and fallow details are shown in Figure 1.

Maize, Spring oats	(maize/oats ratio 1:1)
Maize, Spring oats, Autumn oats	(maize/oats ratio 1:2)

Maize, Maize, Spring oats	(maize/oats ratio 2:1)
Maize, Spring oats, Red clover	(cf. 1)
Maize, Spring oats, Red clover, Autumn oats	(cf. 2)
Maize, Spring oats, Autumn oats, Red clover	(cf. 2)
Maize, Maize, Spring oats, Red clover	(cf. 3).

All the oat and clover crops are harvested as hay. Plots are one-fourteenth of a hectare and are annually fertilised with superphosphate.

Figure 1. Details of crop and fallow periods for a single plot in each sequence over one complete 12-year cycle for each of seven rotations in a crop sequence experiment at Glen Innes.

Results and discussion

Interaction between effects of clover and the maize/oats crop ratio

The inclusion of clover in each rotation resulted in an increase in mean yield of the maize crop, the differences generally being greater the longer the period under clover (Fig. 2); this is particularly evident in rotations with higher ratios of maize/oats where fewer maize crops per cycle have proved capable of producing more grain (accumulated yield) in every cycle except the first. The greatest differences in the relative productivity between clover and non-clover rotations occurred where there was an equal number of maize and oat crops (rotation 1 *versus* 4). Here the long-term effect recorded was the steep decline in productivity in the non-clover rotation from cycle to cycle (Fig. 2a); the relative mean yield (clover to non-clover) of maize declined progressively from 75% in the first cycle to 37% by the end of the fifth cycle. Although rotations with a maize/oats ratio of 2:1 (rotation 3 *versus 7)* followed a similar pattern (Fig. 2c) the relative decline in productivity was less steep with relative mean yield declining from 80% in the first cycle to a low of 53% in the fourth cycle.

In the rotations combining a maize crop with two oat crops (including the longer duration autumn oats), the results were quite different. At no time did the total yield of maize in the clover rotations (nos. 5 and 6) exceed that of the non-clover rotation (no. 2) and the differences in mean yields were much smaller, being non significant ($P>0.05$) in the second and fifth cycles. There was an overall decline in productivity of the rotation containing the shortest duration of clover (36 months) while the non-clover rotation sustained its yield over the last three cycles. These results suggest that an extra 12 months of oats (one spring oat and one autumn oat crop) maintained the productivity of maize at a level not significantly lower than was achieved by 36 months of clover.

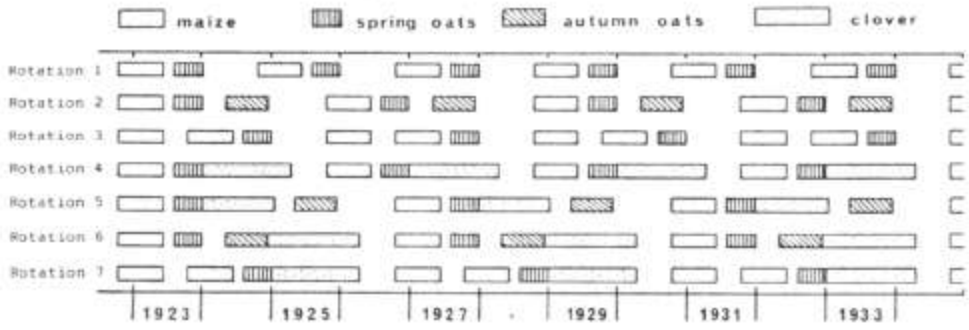

Figure 2. Comparison of mean and total maize yields for each cycle of each series of rotations with (solid symbols) and without (open symbols) clover. Months of fallow (m) for the non-clover rotations and the duration of clover in comparable clover rotations are indicated. The number of crops contributing to total yields is also shown.

Effects of clover on rotations containing the same number of maize crops

It is possible to compare rotations that contain the same number of maize crops but different numbers of oat crops, lengths of clover and fallow (Table 1). Rotations with three maize crops also contained six crops of oats but either 36 (rotation 5) or 48 months (rotation 6) of clover. Rotation 6 slightly out-yielded rotation 5 in all except the middle cycle, although it was significantly more productive only in the final cycle.

Rotations with four maize crops contained either eight or four oat crops and either nil or 60 months of clover respectively (Table 1). The clover rotation (no. 4) out-yielded the non-clover rotation in every cycle, the difference between them increasing to the third cycle and then decreasing. Although the productivity of the clover rotation in the second, third and fourth cycles exceeded that of the first and fifth cycles, there was a continuous decline from the second cycle. On the other hand productivity of the non-clover rotation (including autumn oats) remained virtually unchanged apart from the second cycle. Hence although the productivity of the non-clover rotation was lower than that of the clover rotation, its yield remained stable. This result implies that without clover, four crops of autumn oats (28 months) gave a yield stability comparable to that given by four periods (or 60 months) of clover.

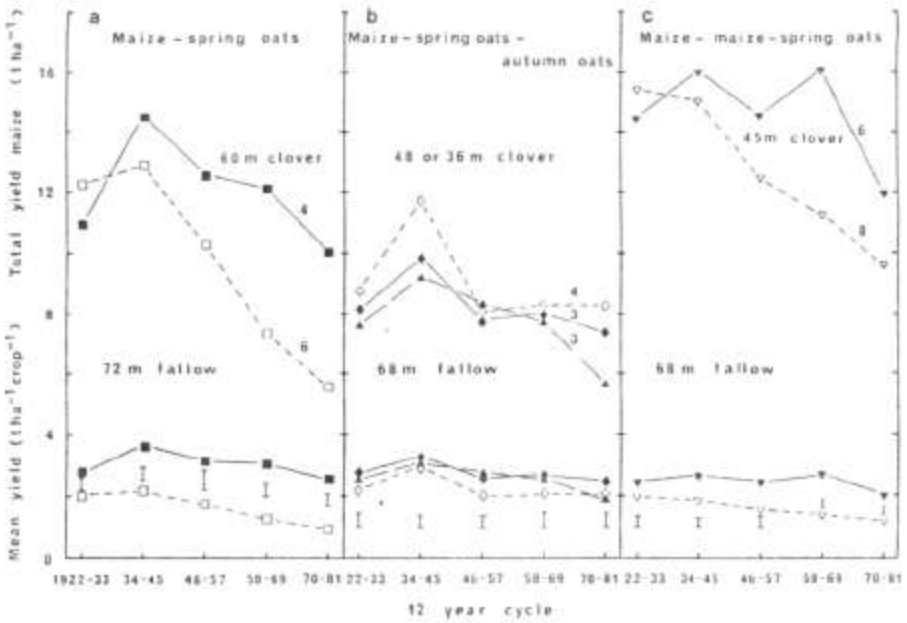

Table 1. Total maize yields (t/ha) over five cycles, each of 12 years, for rotations with the same number of maize crops per cycle but with different numbers of oat crops (both spring and autumn), lengths of clover and fallow.

Rotation treatment	Maize crops	Oat crops	Clover months	Fallow months	Maize yield/cycle 1922-33	34-45	46-57	58-69	70-81
5	3	6	36	51	7.6	9.2	8.3	7.7	5.7
6	3	6	48	39	8.2	9.8	7.8	8.0	7.4
2	4	8	0	68	8.7	11.7	8.1	8.3	8.3
4	4	4	60	36	10.9	14.	12.6	12.1	10.1
1	6	6	0	72	12.3	12.9	10.3	7.3	5.6
7	6	3	45	42	14.5	16.1	14.5	16.1	12.0

Where there were six maize crops in each rotation, a very different result was obtained (Table 1). In the non-clover rotation (no. 1) which contained six spring oat crops, there was a small increase in productivity in the second cycle followed by a steep decline in subsequent cycles to 45% of the original productivity. By contrast the productivity of the clover rotation (no. 7) increased slightly over the first four cycles and then declined to 83% of that recorded in the original cycle. In the final cycle, maize productivity from the non-clover rotation was only 47% of that obtained in the clover rotation.

Conclusions

The inclusion of clover proved beneficial to maize productivity and yield sustainability for most of the experimental period, especially during the first 48 years of the experiment. The inclusion of autumn oats in the rotation also increased maize productivity and sustainability, and in the fifth cycle this effect was

equivalent to that achieved by 36 months of clover. The beneficial effect of autumn oats on maize productivity is consistent with those demonstrated for wheat in long-term experiments in Victoria and South Australia (2). The sustainability aspects of this experiment confirm the value of long term studies in providing basic information and in the opportunity they provide for fundamental studies into factors (e.g., soil parameters) which contribute to such sustainable agricultural practices.

References

1. Anon. 1948. Agric. Gaz. NSW 59, 339-343.

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