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EFFECT OF SEEDING RATE AND NITROGEN ON THE HERBAGE PRODUCTION OF RAIN-GROWN AND IRRIGATED OATS IN SUB-COASTAL SOUTH-EASTERN QUEENSLAND

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SUMMARY

Nitrogen rate rather than seeding rate was the major factor affecting oat forage yield, nitrogen yield and nitrogen recovery under both rain-grown and irrigated conditions on a fertile black earth at Gatton in south-eastern Queensland.

In three consecutive years response to nitrogen was linear up to 67·2 (irrigated) and 33·6 (rain-grown) kg ha^{-1} N per defoliation. Most efficient dry matter production (kg d.m. per kg N applied) occurred at 16·8 kg ha^{-1} N per defoliation under both moisture regimes. Nitrogen recovery was linear up to the maximum nitrogen rate under both moisture regimes. Recovery varied from 31 to 57% under irrigation and from 34 to 59% under rain-grown conditions.

Total dry matter and nitrogen yields of oats generally did not increase significantly beyond a seeding rate of 45 kg ha^{-1} although higher seeding rates did increase yield at the initial defoliation. This could be important where early feed is critical.

I. INTRODUCTION

Oats is the major source of early winter feed in the dairying areas of south-eastern Queensland. Under irrigation, it is usually grown on fertile alluvial flats with low inputs of fertilizer nitrogen, while under rain-grown conditions fertilizer usage is dictated by winter rainfall.

Research in New South Wales has suggested that production under both irrigated and rain-grown situations can be improved by increased seeding rates and applications of up to 67 kg ha^{-1} N per defoliation (Crofts 1966a; Robinson and Sykes 1973; Kemp 1974). The main advantage from higher seeding rates was increased early forage production (Southwood, Mengersen and Milham 1974).

Present recommendations for south-eastern Queensland are 40 to 60 (rain-grown) and 50 to 90 kg (irrigated) of seed per hectare (Anon. 1974), with fertilizer applications of 10 to 20 and 15 to 25 kg ha^{-1} N per defoliation respectively (Anon. 1970). The purpose of these experiments was to evaluate the effects of higher seeding and nitrogen fertilizer rates on early season and total forage production of rain-grown and irrigated oats on a fertile soil in south-eastern Queensland.

II. MATERIALS AND METHODS

Site

The experiments were located at Gatton Research Station on an alluvial black earth (Ug5·1; Northcote 1965). A new experimental area was chosen each year, the sites having different cultivation histories and pre-planting fallows. The 1973 site had a shortened land preparation which resulted in an initial fixation of soil nitrogen.

Design and treatments

A split plot design with four replicates was used for both rain-grown and irrigated experiments. Seeding rates for the rain-grown experiment were 45, 90, 135, 180 and 225 kg ha^{-1}, and constituted the main plots. An additional rate of 22·5 kg ha^{-1} was included in the irrigated experiment. Nitrogen rates (split plots) ranged from nil to 67·2 kg ha^{-1} N per defoliation, the details of rates and numbers of applications per season shown in table 1.

TABLE 1

NITROGEN RATES PER DEFOLIATION AND THE NUMBER OF APPLICATIONS IN EACH GROWING SEASON.

	Nitrogen Rate (kg ha^{-1} N per Defoliation)	Number of Fertilizer Applications					
		Rain-grown			Irrigated		
		1971†	1972	1973	1971†	1972	1973
N_0	Nil	0	0	0	0	0	0
N_1	8·4	..	4	2	..	..	..
N_2	16·8	4	4	2	5	3	5
N_4	33·6	4	4	2	5	3	5
N_6	50·4	..	..	..	5	3	5
N_8	67·2	..	..	..	..	3	5

† In 1971 a basal dressing of 28 kg ha^{-1} N was applied to all plots.

In 1971 a basal dressing of 28 kg ha^{-1} N (as ammonium sulphate) was applied to all plots at planting and differential treatments were imposed after the first sampling. In 1972 and 1973 differential nitrogen treatments (as ammonium nitrate) were applied at planting. Immediately following each sampling the respective nitrogen rates were reapplied by hand broadcasting into the stubble.

Plot sizes were 4·3 m x 6·1 m (rain-grown) and 2·7 m x 4·6 m (irrigated). Treatment modifications in 1972 widened the response range. Minhafer was the variety of oats (*Avena sativa*) chosen because of its average seed size and proven yielding potential in south-eastern Queensland (I. J. L. Wood, personal communication).

Procedures

Mid-season sowings on 29 April 1971, 17 May 1972 and 1 May 1973 were made into fine, firm seedbeds. Seed was hand broadcast and covered by pasture harrows (irrigated) or drilled to 15 mm (rain-grown). Both experiments were irrigated at planting (two 15 mm applications in one week). Irrigation applied (irrigated experiment) between May and October was 238 mm (1971) and 100 mm (1972 and 1973).

When growth on 50% of the treatments exceeded 35 cm in height, a quadrant (0·9 m x 2·4 m—irrigated experiment; 1·8 m x 4·1 m—rain-grown experiment) was cut at 10 cm from each plot with a reciprocating mower and the material weighed. Oven dry weight and nitrogen content (Kjeldahl digestion) were determined on a sub-sample. The area was mown and excess material removed after sampling.

III. RESULTS

Climate

Autumn–early winter rainfall was below average in each year (figure 1). Prolonged waterlogging occurred in October 1972 and July 1973. Temperatures were above average during the three winters.

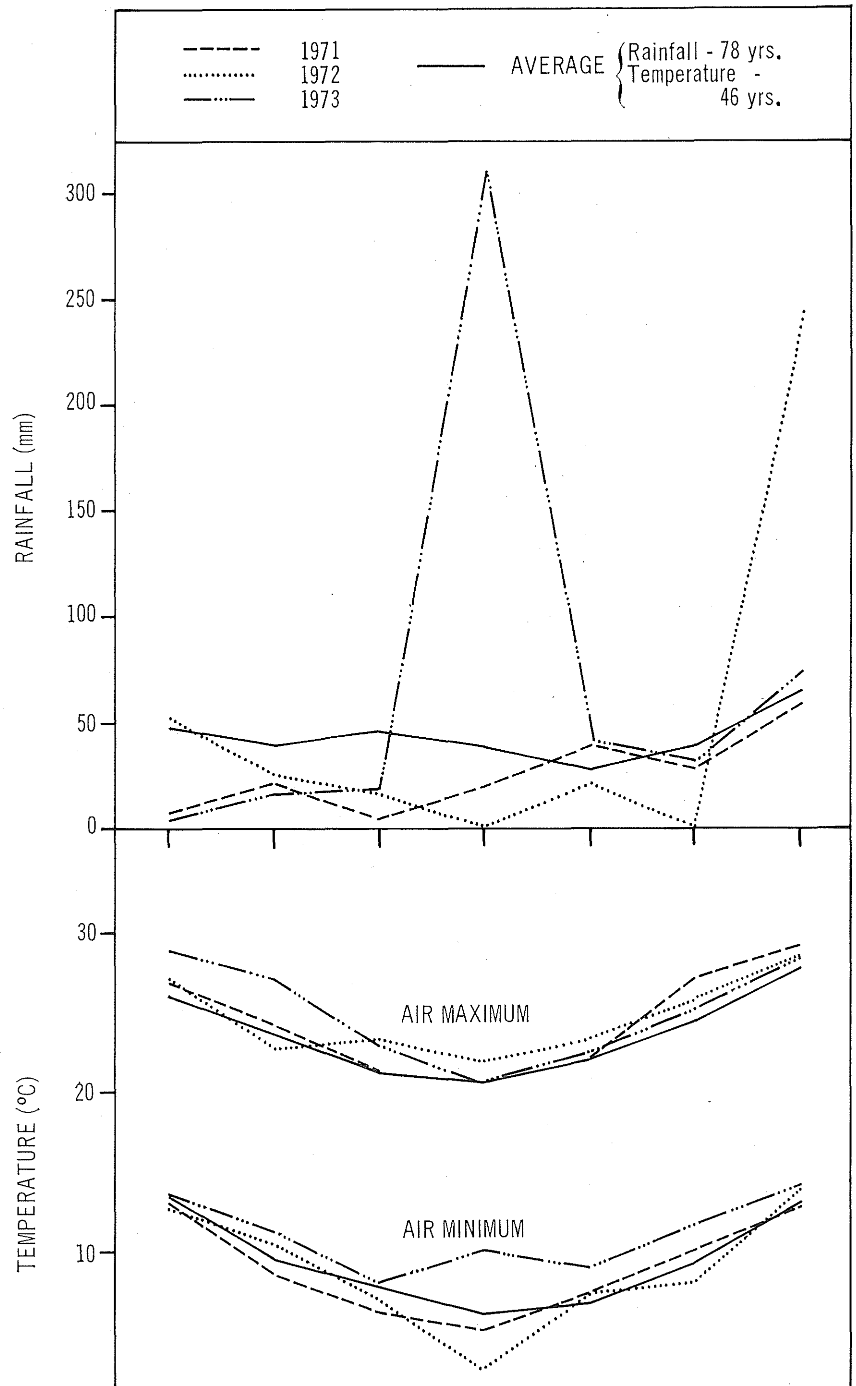

Figure 1.—Rainfall (mm) and temperature (°C) recorded at Gatton Research Station from April to October for the period 1971 to 1973, together with long-term averages.

Dry matter responses to seeding rate

The greatest response to seeding rate occurred at the first sampling under both moisture regimes (table 2), the maximum level of response varying with year and moisture regime. By the second sampling (10 to 20 weeks after planting) these effects had disappeared (data not presented).

TABLE 2

EFFECT OF SEEDING RATE ON DRY MATTER PRODUCTION (t ha^{-1}) OF MINHAFER OATS AT THE FIRST DEFOLIATION.

Seeding Rate (kg ha^{-1})	Rain-grown			Irrigated		
	1971	1972	1973	1971	1972	1973
22·5	..	..	..	..	0·50	0·10
45	0·41	0·95	0·37	0·26	0·96	0·28
90	0·82	1·32	0·48	0·54	1·30	0·43
135	1·03	1·58	0·61	0·83	1·40	0·37
180	1·30	1·75	0·56	1·02	1·54	0·36
225	1·43	1·90	0·54	1·20	1·55	0·50
l.s.d. P = 0·05	0·16	0·20	0·16	0·15	0·20	0·10
Growth period (days) ..	42	49	51	40	37	48

Highest total yields (table 3) in 1971 occurred at a seeding rate of 225 kg ha^{-1} (rain-grown) and 180 kg ha^{-1} (irrigated). However, in 1972 and 1973 seeding rates above 45 kg ha^{-1} had no effect on yields; under irrigation there was a significant increase from the lowest seeding rate increment (22·5 to 45 kg ha^{-1}).

TABLE 3

EFFECT OF SEEDING RATE ON DRY MATTER PRODUCTION AND NITROGEN YIELD OF RAIN-GROWN AND IRRIGATED MINHAFER OATS IN THREE CONSECUTIVE YEARS AT GATTON, SOUTH-EASTERN QUEENSLAND.

Seeding Rate (kg ha^{-1})	Total Dry Matter (t ha^{-1})						Nitrogen Yield (kg ha^{-1})					
	Rain-grown			Irrigated			Rain-grown			Irrigated		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
22·5	..	..	..	..	5·60	2·83	..	..	..	..	194	*
45	5·88	7·81	1·27	8·42	6·99	3·49	203	259	29	298	235	*
90	6·58	7·86	1·33	9·05	6·87	3·43	255	257	34	330	233	*
135	6·73	8·20	1·50	9·36	7·13	3·26	266	266	33	337	247	*
180	7·04	8·18	1·42	10·01	7·68	3·38	287	270	34	368	269	*
225	7·30	8·39	1·41	9·77	7·36	3·30	283	287	31	358	250	*
l.s.d. (P= 0·05)	0·47	ns	ns	0·80	0·91	0·42	19	ns	ns	29	29	*

* Total nitrogen yield figures for 1973 (irrigated) not available.

Dry matter responses to nitrogen

Nitrogen responses differed each year, the greatest response occurring in 1973. However, in all years total dry matter responded linearly to nitrogen under both moisture regimes (figure 2). In 1971 and 1973, yield increases ($P < 0{\cdot}05$) occurred from each successive nitrogen increment. However, in 1972, significant yield increases were recorded only for the increments 0 to 33·6 and 33·6 to 67·2 (irrigated) and 0 to 16·8 (rain-grown) kg ha^{-1} N per defoliation.

Nitrogen content responses to seeding rate and nitrogen level

Increasing rates of nitrogen raised the nitrogen content of oats foliage, the effects increasing after mid-winter in 1971 and 1972. In 1973 the greatest nitrogen content increases occurred early in the season (data not presented). Nitrogen content was unaffected by seeding rate on all occasions.

Nitrogen yield responses to seeding rate

Under rain-grown conditions, nitrogen yield responses were similar to those for dry matter production (table 3), with seeding rate having no effect on nitrogen yield in 1972 and 1973. However, under irrigation, nitrogen yield responses ($P < 0{\cdot}05$) were recorded in 1971 and 1972 up to a seeding rate of 180 kg ha^{-1}. Total figures are not available for 1973 but there was no seeding rate effect in the final three harvests.

Maximum nitrogen yield responses to seeding rate occurred at the initial sampling (data not presented).

Nitrogen yield response to nitrogen rate

Nitrogen yield showed a linear response to nitrogen rate under both moisture regimes (figure 3). Significant increases ($P < 0{\cdot}05$) occurred up to the maximum nitrogen rate in all years.

Seeding rate/nitrogen rate interactions

Few seeding rate x nitrogen interactions were detected in dry matter or nitrogen yield data. When interactions occurred, their effects were small compared with the major treatment effects.

Efficiency of nitrogen recovery

Nitrogen recovery was calculated by the method suggested by Henzell (1963). As nitrogen yield was linearly related to fertilizer rate (figure 3), the equations fitted were linear, of the form:

$$Y = A + BX$$

where Y = nitrogen yield of top material, and X = rate of nitrogen fertilizer. By Henzell's definition, percentage recovery is equal to 100B.

Except in the rain-grown experiment in 1971, the correlation coefficients between nitrogen yield and rate of nitrogen fertilizer were significant (table 4). Nitrogen recovery varied from 31 to 57% under irrigation and 35 to 59% under rain-grown conditions.

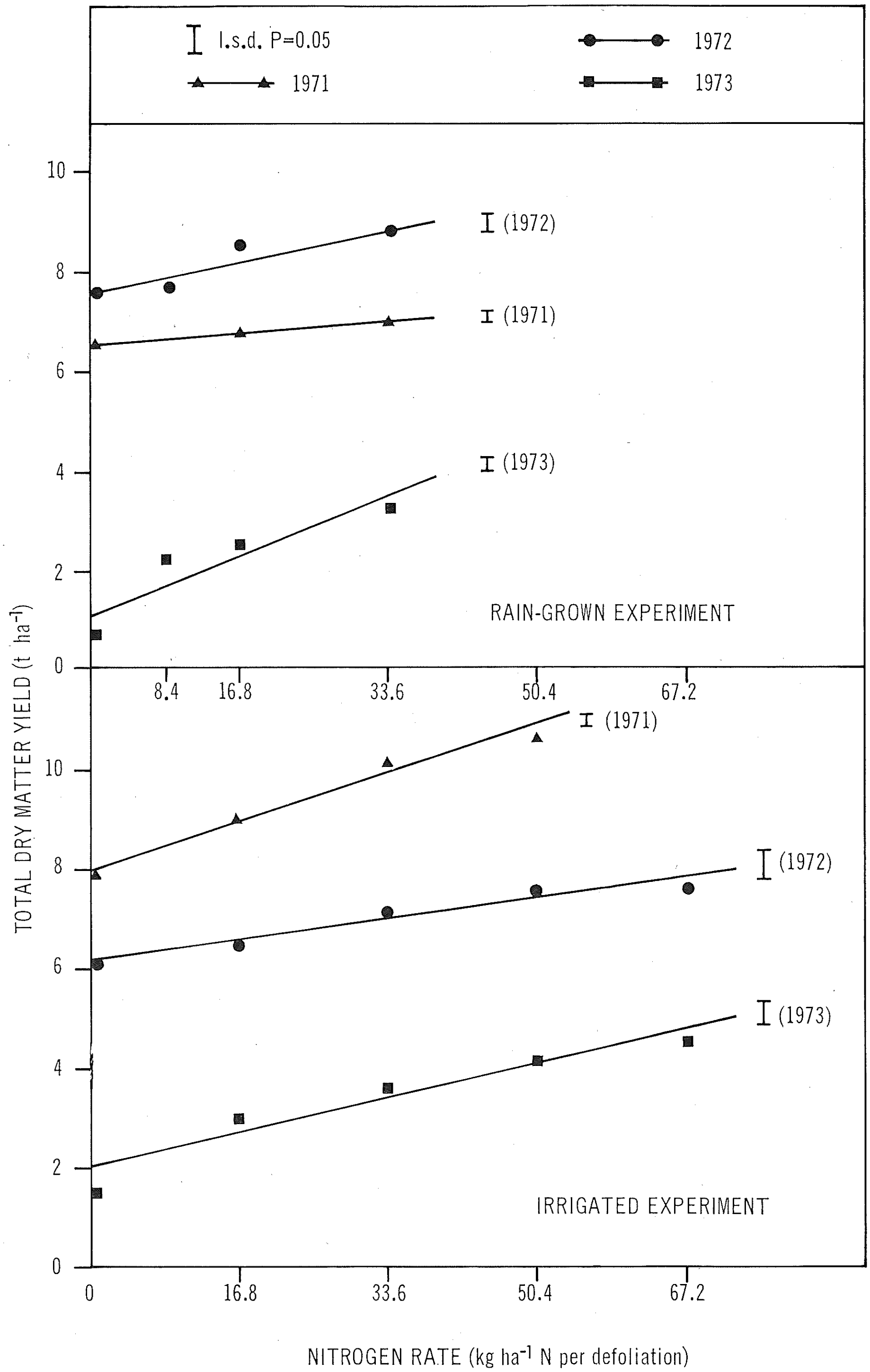

Figure 2.—The effect of nitrogen rates (kg ha^{-1} N per defoliation) on total dry matter production (t ha^{-1}) of rain-grown and irrigated Minhafer oats over three consecutive winter periods.

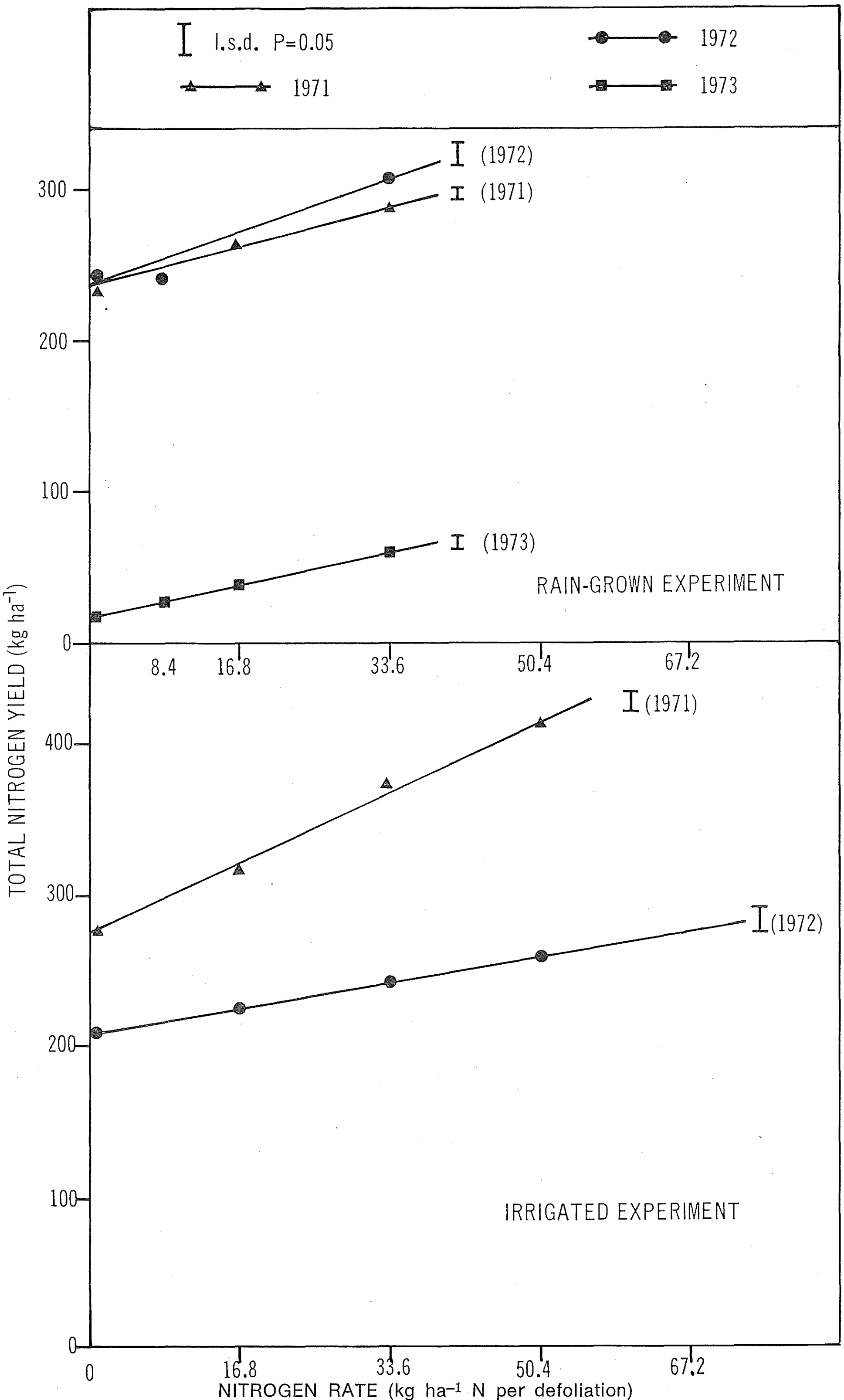

Figure 3.—The effect of nitrogen rate (kg ha^{-1} N per defoliation) on total nitrogen yield (kg ha^{-1}) of rain-grown and irrigated Minhafer oats grown on a fertile soil at Gatton, south-eastern Queensland.

TABLE 4

PERCENTAGE NITROGEN RECOVERY IN OATS FOLIAGE GROWN UNDER IRRIGATION AND RAIN-GROWN CONDITIONS ON A FERTILE BLACK EARTH

Experiment	B +	Signif. +	K +	% N Recovery	r +
Irrigation—1971	0·5700	**	20	57·00	0·9985
Irrigation—1972	0·3143	**	18	31·43	0·9957
Rain-grown—1971 ..	0·3468	NS	20	34·68	0·9961
Rain-grown—1972 ..	0·5014	*	20	50·14	0·9792
Rain-grown—1973 ..	0·5949	**	20	59·49	0·9999

+ (B = slope of the linear equation; K = number of observations; r = correlation co-efficient; ** = significant at the 1% level; * = significant at the 5% level; NS = not significant.)

IV. DISCUSSION

Average seasonal rain-grown production (5 400 kg ha^{-1}) was higher than that recorded from northern New South Wales (Robinson and Sykes 1973; Kemp 1974) but under irrigation, growth rates were similar (Crofts, Laing and Kelleher 1970). Despite the higher average temperatures it appears that oats is capable of high dry matter production in sub-tropical environments.

Although oats is normally a reliable winter feed in sub-coastal south-eastern Queensland, production in this experiment varied considerably from year to year. Adverse conditions in 1972 were late enough not to seriously affect total yield. In 1973 they occurred in mid-winter, the resulting disease problems (mainly leaf and stem rust) cutting short the growth of the rain-grown experiment and reducing yield under irrigation. In West Moreton there is only a 2% chance of a similar situation occurring in mid-winter (Bureau of Meteorology, unpublished data).

Seeding rate effects

On fully prepared seedbeds, seeding rates above 45 kg ha^{-1} had little effect on total production except in 1971. A cooler autumn and an earlier planting date may explain the greater response in the first year. The response to seeding rate early in the season may justify the use of the high seeding rates if early feed is important. However if weather permits, earlier plantings may be a more economic method of providing early feed (Crofts 1966a; Robinson and Sykes 1973).

Nitrogen rate effects

Significant nitrogen responses from oats were demonstrated under both rain-grown and irrigated conditions on what is considered an extremely fertile soil. As most West Moreton soils where oats are grown are less fertile than that at the experimental site, it follows that increased nitrogen usage would improve cool season feed production in most commercial situations.

Efficiency of dry matter production

The most efficient dry matter production, defined by Henzell (1963) as the increase in dry matter production per unit of nitrogen, occurred at 16·8 kg ha^{-1} N per defoliation under both moisture regimes (table 5). Efficiency decreased rapidly at rates of nitrogen above this level except under rain-grown conditions in 1973. The improved efficiency at higher rates in this instance was due to the shortened growing season and therefore to the lower total nitrogen applied.

The levels of dry matter efficiency obtained here were similar to those obtained in coastal south-eastern Queensland (C. H. Middleton, personal communication) but slightly lower than those obtained in cooler areas of New South Wales (Colman 1966; Crofts 1966b; Kemp 1974; Southwood, Mengersen and Milham 1974). Values were very much lower than those obtained for warm season grasses (Henzell 1963).

TABLE 5

EFFICIENCY OF DRY MATTER PRODUCTION OF MINHAFER OATS (IN kg OF DRY MATTER per kg OF NITROGEN APPLIED) IN RESPONSE TO NITROGEN FERTILIZER RATES.

Nitrogen Rate Increment (kg ha^{-1} N per defoliation)	Rain-grown			Irrigated		
	1971	1972	1973	1971	1972	1973
0—8·4	..	7·0	27·2	..	..	..
0—16·8	..	..	..	13·3	8·8	19·3
8·4—16·8	4·8	20·5	27·2	..	..	..
16·8—33·6	3·5	1·1	20·5	12·6	10·9	6·5
33·6—50·4	..	..	..	6·0	7·3	5·5
50·4—67·2	..	..	..	..	3·0	5·8
l.s.d. P = 0·05	ns	13·4	ns	5·4	ns	6·3

Nitrogen content in foliage

Levels of nitrogen in unfertilized foliage rarely fell below 2·4%, suggested by Kemp (1974) as the level required for high dairy cow production. If land preparation is inadequate, with undecomposed plant material remaining (as occurred in 1973) higher rates of nitrogen may be required, even on fertile soils, to maintain plant nitrogen levels early in the season.

Efficiency of nitrogen recovery

Nitrogen recovery appeared to be influenced more by seasonal conditions than by source of nitrogen, with the highest nitrogen recovery achieved from ammonium sulphate and ammonium nitrate being equivalent. The lower nitrogen recovery under irrigation compared with that under rain-grown conditions in 1972 appears to be associated with the loss of production from the final growth period in the irrigated experiment as a result of waterlogging. Levels of recovery in this experiment were similar to those obtained by Colman (1966), Crofts (1966b) and C. H. Middleton (personal communication) for rain-grown oats, but higher than those obtained by Blunt and Fisher (1976) for irrigated oats.

V. CONCLUSIONS

In sub-coastal south-eastern Queensland, it seems that oats will respond to applications of up to 33·6 kg ha^{-1} N per defoliation under rain-grown conditions and 67·2 kg ha^{-1} N per defoliation under irrigation although most efficient nitrogen use occurs at 16·8 kg ha^{-1} N per defoliation. In times of feed shortage, higher rates than this last value will undoubtedly justify the increased fertilizer cost.

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