Effects of water and nitrogen on lodging, head numbers and seed yield of high and nil endophyte perennial ryegrass

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Abstract

Following a six-week period of water stress from spikelet initiation to reproductive head emergence seed yields of perennial ryegrass (*Lolium perenne* L) were reduced by 31-62% compared to irrigated plots which received 130 mm of water during this period. Nitrogen (N) had no effect on seed yields in dryland plots, but significantly increased yields from 850 (nil nitrogen) to over 2000 kg/ha for 120 and 180 kg N/ha treatments. Lodging was significantly increased by nitrogen and irrigation. Seed yields were similar for high and low endophyte, despite a moderate/high population of Argentine stem weevil.

Additional key words: *Argentine stem weevil, irrigation*

Introduction

There has been little published research on perennial ryegrass (*Lolium perenne* L.) seed production in New Zealand (NZ) in the last 10 years. The most recent papers reported seed yields that are now regarded as relatively low; 630-1200 kg/ha (Brown, 1981) and 550-1460 kg/ha (Hampton, 1986). While approximately 50% of ryegrass seed crops in NZ are grown with irrigation, there have been no studies on soil moisture needed to optimise seed yields. Recommendations to seed growers are currently based on cereal water use models.

A survey in 1990/91 suggested that nitrogen (N) usage was limiting seed yield on 30% of crops surveyed (Rowarth, 1992). Higher rates of N increase lodging and early lodging is thought to limit seed yields (Hebblethwaite, 1987).

Argentine stem weevil (ASW) (*Listronotus bonariensis* Kuschel) larvae are very active on ryegrass that is lacking the endophytic fungus *Acremonium lolii* Latch, Christensen and Samuels. With the area of non-endophyte ryegrass' in seed production increasing (L. Rosevear, pers. comm.) there is a need to determine if ASW has a detrimental effect on seed production.

Methods

Perennial ryegrass cv. Grasslands Nui was sown at Lincoln (lat 43°S) on 26 March 1993 at 10 kg seed/ha with chlorpyrifos (Suscon G, 15 kg/ha) for grass grub (*Costelytra zealandica* White) control. The trial was established on an Eyre/Templeton complex soil type in two adjacent areas, one of which was irrigated, and the other dryland. Within each area treatments consisted of 2 endophyte levels, nil and high (70% endophyte); and 4 nitrogen rates with a total of 0, 60, 120 or 180 kg N/ha as urea split in to 3 equal amounts applied on the 8 and 22 September, and 6 October. Treatments were replicated five times in a randomised block design. Plot sizes were 11m x 5m with 1m between plots. An establishment count at 21 September recorded 225 plants/m^2 (43-46% of the viable seeds sown).

Results of a soil test (MAF Quick Test) in July 1993 were: pH 5.8, Olsen P 17, K 12, S 6, NH_4 1 µg/g, NO_3 1 µg/g.

Weeds were controlled with ethofumesate 2 kg ai/ha (21 June), and 3 litres Salvo (107 g/l MCPA, 210 g/l mecoprop, 233 g/l dichlorprop, 17 g/l dicamba) applied 10 September.

The plant growth regulator, chlormequat (3.0 kg ai/ha), and the fungicide, propiconazole (0.125 kg/ha ai) were applied as a tank mix on 27 September. Propiconazole (0.125 g ai/ha) was reapplied on 1 December.

Irrigation was applied on three occasions, totalling 130 mm from 22 October - 19 November, to maintain the soil near field capacity. Regular rains after this meant additional irrigation was not needed. Soil moisture was monitored weekly from 18 October using a neutron probe and TDR (time domain reflectometer) with 8 dryland and 8 irrigated recording sites. Soil moisture potential deficit was calculated from rainfall and evaporation recorded 2 km from the site for the period 1 September to 31 December 1993.

Foliar N concentrations were analysed (Soil Fertility Service, Invermay) regularly from 7 June. Lodging scores were recorded weekly from 2 November. Quadrats (0.25 m^2) were cut at anthesis to determine reproductive tiller numbers and weight, and spikelet and floret numbers per head.

Seed was harvested on 3 January 1994 (dryland) and 5 January (irrigated) at 40-42% seed moisture content, by cutting and bulking 3 quadrats each 0.25 m^2 per plot. Samples were air dried and then threshed and cleaned. Purity, germination, seed moisture and TSW (thousand seed weight) were determined by counting 3 lots of 100 seeds.

ASW numbers were determined from two vacuumed quadrats each 0.25 m^2 per plot harvest in April 1994, and parasitism from *Microctonus hyperodae* Loan (Goldson *et al.*, 1990) recorded.

Results and Discussion

Moisture Stress

On this soil type field capacity occurs at 36%, while permanent wilting point is at 15% (Glyn Francis, pers. comm.). The onset of moisture stress was from initiation/stem elongation in late September and continued until just before anthesis six weeks later, (Fig. 1) when regular rainfall increased soil moisture in the dryland plots from 9% (25 November) to 24% (2 December). Irrigated plots ranged from 24-36% soil moisture in this period. Irrigation increased seed yields by 510-840 kg/ha (31-62%) across treatments receiving N (Table 1). Reproductive head numbers were greater by 140-490/m^2 (9-55%) on dryland plots than irrigated plots, but this was not translated into seed yield nor did it affect the proportion of small seed (Roy *et al.*, 1994). This needs further investigation.

Nitrogen

The nil nitrogen dryland plots had 40% more heads and produced 53% more seed (Table 1) than the nil nitrogen irrigated plots, suggesting that under N stress irrigated plots are partitioning nutrients to vegetative growth while dryland plots are partitioning nutrients to reproductive growth.

The ryegrass in the trial had foliar N concentrations of 3.4-4.8% during June to early September. There was no seed yield response to additional N in the dryland treatments. Foliar N concentrations in the dryland plots were similar (no more than 0.15% N difference to irrigated plots) for any of the applied N treatments, indicating N uptake was not limiting the response. When the rains returned the dryland plots with applied N were observed to produce considerable new vegetative growth which would have made machine harvesting of the high N plots difficult.

With irrigation increasing amounts of applied N had a positive effect on seed yield. For this site and year the optimum N rate was 120 kg/ha, similar to the amount

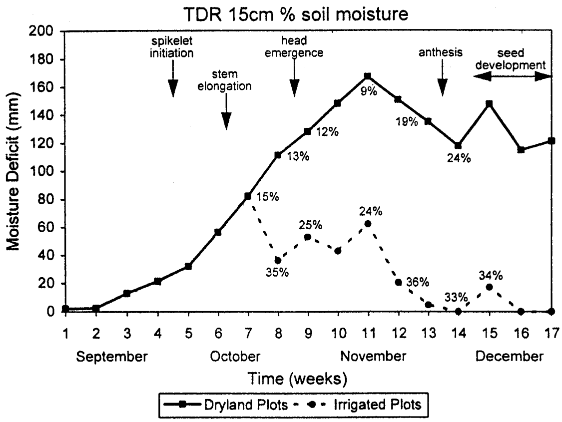

Figure 1. Change in potential soil moisture deficit and soil moisture in the top 15 cm during September-December 1993.

Table 1. Effect of N application rate on seed head density and seed yield for irrigated and dryland areas.

N rate (kg/ha)	Heads per m^2 Irrigated	Heads per m^2 Dryland	Seed yield (kg/ha) Irrigated	Seed yield (kg/ha) Dryland
0	1210	1700	860	1320
60	1480	1620	1860	1320
120	1490	2310	2150	1640
180	1770	1920	2200	1360
LSD 5%	-	-	280	391

calculated by Hampton (1987) as optimum for perennial ryegrass seed crops. The seed yield reported in this trial are high by New Zealand standards and the seeds had a high TSW (>2.0 g). However, while high seed yields (in excess of 2000 kg/ha) were achieved, the productive head density in the irrigated plots was relatively low (1480-1770/m^2). It is possible that more N would be required to supply a higher reproductive head density of 2000-4000/m^2, which has been reported as the non-limiting head density for perennial ryegrass seed crops (Hampton & Hebblethwaite, 1983).

A kilogram of nitrogen costs $1.10 (as urea) which is equivalent to the value of 0.75-0.9 kg of seed, giving a cost benefit ratio of 1:12 ($12 return per $1 spent on N in the irrigated 120 kg N treatment when ryegrass returns $1.30/kg).

Lodging

Lodging occurred early (pre-anthesis) on irrigated plots and the severity increased with the rate of N (Fig 2); lodging was minimal in the dryland plots. There is little indication from the data that lodging limited seed yield in the trial. However, the effect of lodging cannot be adequately evaluated without comparison with treatments that are prevented from lodging, either through mechanical support or with a stem shortening plant growth regulator.

Endophyte

ASW populations were 70-80 weevils/m^2 on non-endophyte plots with 20% parasitism. This population is thought to be high enough to cause considerable tiller death in pastures (S. Goldson pers. comm.). However, there was no significant difference in seed yield between nil and high endophyte plots. ASW larval numbers are generally low in October-November, and their accumulated density for 1993/94 was intermediate (N.D. Barlow, pers. comm.) and the first year seed crop probably escaped significant damage before the second generation ASW larval population develops in January.

Conclusion

Moisture stress from the elongation growth stage had a large negative effect on seed yield. Nitrogen response was affected by moisture; with irrigation there was a large seed yield increase to increasing N, with a good economic return. Lodging was increased with irrigation and nitrogen combined. Moderate-high Argentine stem weevil populations had no effect on an autumn sown first year harvest.

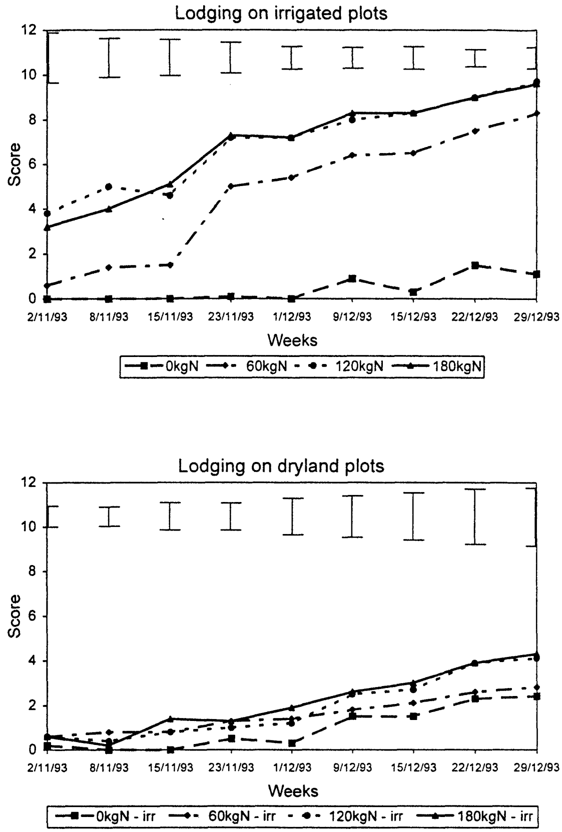

Figure 2. Degree of lodging on irrigated and dryland plots recorded at weekly intervals from 2 November 1993.

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