Ryegrass seed yield loss due to under-sized seed

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Abstract

In ryegrass (*Lolium perenne* L.) there remains a wide gap between potential and actual seed yield. Losses in potential seed yield are usually attributed to the abortion of immature seed or shattering losses at maturity. A seed production trial involving irrigated or rainfed conditions was used to study floret site utilisation and seed losses due to small, double or light seeds. Seed yields were 860-2200 kg/ha. Out of the range of 202-452 thousand florets/m^2, only 20-33 % of florets produced seeds with a thousand seed weight (TSW) of >2.0 g. Small (TSW <1.25 g), double (more than one seed or seed with a bract) and light seed (TSW< 0.75 g) accounted for 2.9-6.0, 0.4-0.8 and 1.6-3.0 % of the total, respectively, irrespective of irrigation. The total floret site utilisation (florets containing a seed) was 30.0-38.5 %. The small and double seeds, which were influenced by both irrigation and nitrogen, had germinations of 72-84 %, TSWs of 1.08-1.12g and comprised 118-170 kg and 24-57 kg/ha, respectively. Light seeds with TSWs of 0.61-0.65g and germinations of 10-12 % comprised 21-57kg/ha. In this study only 6-10 % of potential yield was wasted because of the failure to achieve a TSW that is saleable.

Additional key words: *Floret site utilisation, light seed, potential seed yield, undersized seed, ryegrass, nitrogen, irrigation*

Introduction

Large differences exist between theoretical and actual seed yield in perennial ryegrass (*Lolium perenne* L.), the magnitude depending mostly on the degree of floret site utilisation (Elgersma, 1991). Floret site utilisation in ryegrass and other grass species depends on genetic (Elgersma *et al.*, 1989; Elgersma and Sniezko, 1988), environmental (Hebblethwaite, 1985, 1987; Meijer, 1985) or management (Brown and Rolston, 1985; Hampton and Hebblethwaite, 1983, 1985; Burbidge *et al.*, 1978) factors. Ovule degeneration or shortage of assimilate supply during seed growth results in empty or light seeds (Elgersma and Sniezko, 1988). Foliar disease attack, especially stem rust, can aggravate the situation and spraying of appropriate fungicide as a preventive measure can improve floret site utilisation (Mares Martin and Gamble, 1993). Minimum temperature at or up to one week after anthesis was reported to be the main environmental factor related to seed yield (Hampton and Hebblethwaite, 1983) but the precise effect of low temperature is unclear (Hebblethwaite, 1985). A severe reduction in floret fertility of tall fescue due to frost during ear emergence and anthesis has been reported (Hare, 1993).

Management factors at or before anthesis also play an important role in floret site utilisation, seed growth and ultimate yield. Nitrogen application (Hampton, 1987; Hebblethwaite, 1985; Rolston *et al.*, 1985) and use of growth regulators at or before anthesis (Hampton and Hebblethwaite, 1985) are known to increase floret site utilisation and seed yield in perennial ryegrass.

The present study was undertaken to estimate the floret production and utilisation in the form of seed from a field crop of perennial ryegrass.

Materials and Methods

A field experiment was conducted at AgResearch Lincoln, New Zealand during 1993/94. Details of the trial are presented in Rolston *et al.* (1994). In brief, perennial ryegrass (cv. Grasslands Nui) was sown on 26 March 1993 in 15 cm rows at 10 kg/ha in a randomised complete block design with five replicates and five nitrogen treatments (0, 60, 120, 180 or 120 (slow release) kg/ha of N), and two irrigation regimes (none or with irrigation maintaining soil moisture between 100 % and 60 % of field capacity). Plots were 10 m x 5 m. A plant growth regulator, cycocel (chlormequat chloride at 3.0 kg a.i./ha), plus a fungicide (Tilt-propiconazole 125 g a.i./ha) were applied on 27 September. A second application of propiconazole (125 g a.i./ha) was made on 1 December 1993. Three irrigations (total 135 mm water) were made during a six-week dry spell from the begining of October to mid November.

At anthesis (16 November 1993), two 1 metre row samples per plot were hand-harvested to measure herbage growth and number of tillers. From a subsample of 20 heads the total number of spikelets per head was counted. Florets per spikelet from the top, middle and bottom positions of the spikelets were counted and mean floret number per head was calculated, i.e., number of heads/m^2 x number of spikelets/head x number of florets/spikelet. Final harvest of 0.90 m^2 area was made by hand when the seeds were at 42-45 % seed moisture content on 3 and 5 January 1994 for rainfed and irrigated plots, respectively. The samples were then air-dried for two weeks and threshed in a sample thresher. During seed cleaning at 800 revolutions/minute using a Kamas Westrup type LA-LST indented cylinder, the small (TSW < 1.25 g), double (more than one seed or seed and bract attached) and light seed (TSW < 0.75 g) was saved to determine the seed loss and to calculate percentage recovery from florets. The purity, thousand seed weight (TSW) and germination percentages of all grades of seed were determined as per standard International Seed Testing Association (ISTA, 1993) procedures. For the germination test of double seeds, only the seeds were taken into account and the bract or other parts were not considered. Floret site utilisation (FSU) was determined as follows:

$$FSU = (G+S+D+L) / F$$

where G is the number of good (TSW > 2.0 g) seeds/m^2, S is small seeds/m^2, D is double, S is light seeds/m^2 and F is thenumber of potential florets/m^2

Statistical analyses were made separately for irrigated and rainfed conditions using GENSTAT.

Results and Discussion

Seed yields were 1600-2200 kg/ha (Table 1). Losses from shattering were observed to be negligible at the time of harvest, as were losses that occurred at threshing with seed that did not separate from straw. Further the equipment used for seed cleaning allowed for a 100 % recovery of seeds in the designated fractions.

Floret production averaged 340 thousand/m^2 (range 203-452 thousand), and was similar in irrigated (329 thousand) and rainfed treatments (357 thousand) (Table

Table 1. Effect of different rates of nitrogen (kg/ha) on perennial ryegrass seed yield, floret number and the percentage of florets containing the different seed categories under irrigated and rainfed conditions.

Treatments	Seed yield (kg/ha)	Florets/m^2 ('000)	% florets with seeds Saleable	Small	Light	Double	total	% failed florets
Irrigated								
N0	862	203	22.8	6.0	2.0	0.7	31.5	68.5
N60	1853	311	30.0	4.5	2.5	0.8	36.7	63.3
N120	2153	324	33.1	4.1	2.7	0.8	38.3	61.7
N180	2197	372	28.5	4.7	3.0	0.8	37.2	62.8
N120 (SL)	2187	435	24.2	3.3	1.8	0.7	29.9	70.1
LSD (0.05)	284.0	84.7	7.30	1.40	0.89	0.24	8.65	8.65
Rainfed								
N0	1326	318	22.0	4.5	1.6	0.4	28.4	71.6
N60	1318	301	22.5	3.8	1.8	0.4	28.5	71.5
N120	1635	452	19.7	3.0	1.7	0.4	24.5	75.5
N180	1356	344	20.5	2.9	2.3	0.5	26.4	73.6
N120 (SL)	1590	369	22.5	3.2	1.6	0.4	27.7	72.3
LSD (0.05)	391.2	95.2	7.82	1.09	0.71	0.18	8.68	8.68

1). This floret density is also similar to those reported by Hampton (1987), Hebblethwaite *et al.* (1980) and Meijer (1985). Of the florets produced, 27.7 % (irrigated) and 21.4 % (rainfed) were recovered as saleable seed, while small, light and double seeds together accounted for only 5-10 % of the total florets produced. The total florets recovered ranged from 25-38 % across all treatments, leaving 62-76 % of florets that failed to produce a harvestable caryopsis. These results are within the range of 12-41 % reported by Elgersma (1990), Hampton (1987), and Horeman (1989) in different environmental conditions.

Seed yield losses due to undersized seed were largely attributable to small seed, and averaged 125 kg/ha with an average germination of 77 % and a TSW of 1.07 g (Table 2). The germination of this fraction was only 7 % lower than the saleable seed, despite the low TSW. The light and double seeds together averaged 75 kg/ha.

The quantities of seed wasted as a percentage of saleable seed were relatively small (6.0-10.7 %). If the small seed fraction in this trial is considered to be marketable as second grade seed with a per kg value of between 50-75 % of the saleable seed, then the percentage wastage as under-sized seed is only 6 %. This is in marked contrast to work in prairie grass (*Bromus willdenowii* Kunth) where Brown and Rolston (1985) reported that 66 % of recovered florets were in the under-sized seed fraction.

The under-sized seed fraction remained relatively constant over a wide seed yield range (860-2200 kg/ha), suggesting that these losses are inevitable, and are probably associated with later flowering florets, or terminal florets within the spikelet.

Conclusion

Where nitrogen was used, less than 10 % of the actual seed yield was wasted because of the failure of small seed to achieve a weight that was saleable. From the present study it was also evident that between 62 and 76 % of the florets present at anthesis did not produce a seed. Their fate deserves attention in future research.

The results suggest that improving nutrition to undersized seed will have a minor effect on increasing seed yield. However, increasing FSU (assuming no marked increase in percentage of undersized seed) could have a major effect in increasing small seed percentage. Possible areas of exploration could be the synergistic effects of nitrogen, water, plant growth regulators and fungicides on reducing lodging, increasing FSU and in increasing seed yield, and the solving of the paradox - breeding ryegrass cultivars that produce good seed yields as well as desirable vegetative and reproductive characteristics like short stature and compact heads.

Table 2. Effect of different rates of nitrogen (kg/ha) on different categories of "waste" seeds, thousand seed weight (TSW) and germination percentages under irrigated and rainfed conditions.

	"Waste" seed type (kg/ha)			TSW (g)		Germination (%)		
Treatments	Small	Light	Double	Small	Light	Small	Double	Light
Irrigated								
N0	118	21	24	1.08	0.63	72	82	10
N60	142	43	46	1.12	0.64	84	98	10
N120	141	49	52	1.22	0.62	83	82	12
N180	169	57	56	1.07	0.63	79	76	9
N120 (SL)	144	41	56	1.05	0.61	81	76	14
LSD (0.05)	27.7	13.5	12.4	0.06	0.0	6.2	8.65	5.5
Rainfed								
N0	137	25	19	1.11	0.56	76	80	8
N60	114	32	22	1.06	0.62	78	80	8
N120	114	39	35	1.02	0.63	76	64	8
N180	94	41	32	0.97	0.62	69	74	12
N120 (SL)	97	37	31	1.00	0.66	72	76	10
LSD (0.05)	20.8	15.9	9.2	0.06	0.04	7.5	8.08	5.8

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