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Arable Update

Herbage: Issue 82

Irrigation management for browntop seed crops

Background

Browntop (*Agrostis capillaris*), a fine-leaved perennial grass, is widely used in the turf industry because it has tolerance to low mowing and treading. Unlike many temperate grass species, browntop is a late-flowering species, typically harvested in March, which means crop management extends through the hot and dry summer period (Guy *et al*., 1990).

Browntop shares physiological traits with ryegrass, but its drought response mechanisms are not well understood. Previous research has identified rainfall/irrigation as the primary constraint on browntop seed yield, with significant variability observed across soil types and farm management practices (Guy *et al*., 1990; Rolston *et al*., 1998). Nitrogen application and stubble management can influence seed yield and thousand-seed weight, but these effects are strongly influenced by environmental conditions, particularly water availability.

Water stress is a recurrent constraint to seed production on the east coast of New Zealand, particularly in regions such as Canterbury, where evapotranspiration frequently exceeds precipiation during the critical growth months of spring and early summer. Under these conditions, soil moisture reserves are rapidly depleted, and if water availability in the root zone fails to meet crop demand, physiological responses such as wilting, accelerated leaf senescence, and tiller mortality may occur, ultimately compromising seed yield.

This Herbage Update summarises findings from three seasons of irrigation on browntop trials in Canterbury, New Zealand. The research aimed to quantify water use and assess the impact of early to mid-season drought on final seed production and to identify if other crops in the rotation could be prioritised for irrigation in early summer.

Key points

- Browntop seed yield on Templeton Silt Loam soils increased with irrigation across three seasons, with optimal results achieved from 334 to 486 mm of water applied.
- On average, crops required around 400 mm of irrigation from September to harvest, reflecting the higher water demand associated with browntop's late maturity.
- Seed yield consistently dropped once the critical soil moisture deficit (Dc) of 54 mm was exceeded, regardless of when drought occurred, indicating that browntop seed crops are less drought-tolerant than ryegrass, wheat, or cocksfoot (critical deficit ≥70 mm at the same site).
- Continuous irrigation is essential throughout the season, particularly during hot, dry periods, to prevent stress at any growth stage and maintain seed yield.
- Higher seed yields were associated with greater seed head numbers and branching, resulting in more seeds per square metre.

Methods

Three field experiments were undertaken over consecutive seasons (2013-14, 2014-15, and 2015-16) at the FAR Arable Site, Chertsey, Canterbury, New Zealand. The experiment was undertaken on browntop 'Arrowtown' and was drilled on 13 March 2013 at 3 kg/ha and in 15 cm rows using a small plot drill. The experimental design was a randomised complete block with four replicates consisting of seven treatments.

The soil was a Templeton silt loam with approx. 60 cm topsoil over free-draining gravel and a water-holding capacity of approximately 120 mm (Lilburne *et al*., 2012). Irrigation was applied via trickle tapes located between rows at an application rate of 12 mm/hr. Irrigation was scheduled using potential soil moisture deficit (PSMD) calculated from evapotranspiration and rainfall, and verified by weekly neutron probe readings (0–60 cm). The profile was generally restored to field capacity during winter rainfall (Table 1). Management followed standard best practices with ~50 kg N/ha applied in the autumn and 160 kg N/ha applied during spring, up to 1.2 L/ha Moddus (a.i. 250 g/L trinexapac ethyl) plant growth regulator applied for lodging control and a two – three spray preventative fungicide programme implemented for stem rust control.

Harvesting followed a consistent procedure each year: plots were windrowed at the hard dough stage and harvested 6–12 days later with a plot combine. Subsamples were machine-dressed to first-generation seed certification standards and expressed as kg/ha. Thousand seed weight (TSW) was determined from 200 seeds weighed to four decimal places.

Potential ET (PET) was estimated using the Priestley–Taylor method (Jamieson, 1982), and the potential soil moisture deficit (PSMD) calculated by adding daily PET throughout the growing season while subtracting rainfall and irrigation, with the maximum seasonal deficits recorded as maximum potential soil moisture deficit (MPSMD). Seed yield and component data were analysed by ANOVA, with significant differences ($P<0.05$) separated using LSD (Seabold and Perktold, 2010).

Table 1. Monthly rainfall and calculated potential evapotranspiration (PET) from for three growing seasons, recorded at the FAR Arable Site, Chertsey, New Zealand.

	2013-2014			2014-2015			2015-2016		
Month	**Rainfall**	**PET[1]**	**Deficit[2]**	**Rainfall**	**PET**	**Deficit**	**Rainfall**	**PET**	**Deficit**
April	65	54	12	167	39	127	103	59	44
May	93	33	60	54	39	16	9	36	-26
June	246	20	225	60	34	27	79	23	57
July	38	34	4	33	34	-1	47	26	21
August	37	40	-3	21	32	-11	58	37	21
September	31	71	-40	18	76	-58	73	52	21
October	64	106	-42	20	108	-89	10	109	-99
November	45	127	-82	41	146	-105	14	120	-106
December	88	147	-59	26	97	-71	43	137	-95
January	33	163	-130	13	102	-90	84	48	36
February	18	120	-102	49	96	-47	5	130	-125
March	85	55	30	56	69	-13	30	61	-31
Seasonal total	844	971	-127	557	872	-315	555	837	-282
Sept - harvest	364	789	-425	221	694	-472	259	658	-399

Note: [1]Monthly PET values calculated using the Priestly Taylor method. [2]Positive monthly deficit equals soil moisture recharge while negative monthly deficit results in soil moisture draw down.

Results and discussion

In Season 1 (2013-14), seed yield increased ($P< 0.05$) from 65 kg/ha in the untreated control to approximately 322 kg/ha in treatments receiving more than 230 mm of irrigation (Table 2). Water stress prior to anthesis reduced seed yield by approximately 70 kg/ha. Replacing 50% of ET post-anthesis did not induce drought stress due to sufficient soil moisture and rainfall.

In Season 2 (2014-15), all irrigation treatments increased seed yield ($P < 0.05$). The untreated control produced only 5 kg/ha, whereas treatments without water stress achieved seed yields exceeding 560 kg/ha. A range of treatments produced between 300 - 400 kg/ha despite differences in the timing of maximum water stress, which ranged from early anthesis in early January to windrowing in early March. To maximize seed yield, more than 430 mm of irrigation was required (Table 2).

In Season 3 (2015-16), the trend mirrored Season 2, with at least 389 mm of irrigation needed to achieve maximum seed yield (Table 2). All drought timing treatments reduced seed yield ($P<0.05$) by approximately 80 kg/ha. The unirrigated plots produced only 10 kg/ha.

Across all seasons, the highest seed yields occurred in treatments that replaced ET losses or applied irrigation to prevent drought stress, requiring on average 412 mm of water. Any drought stress resulted in yield reductions. However, the appropriate application rates varied by season e.g. appropriate irrigation quantities ranged from between 334 to 486 mm depending on seasonal rainfall and ET (Figure 1A).

On Templeton silt loam soils with 60 cm of topsoil over gravel, the critical soil moisture deficit (Dc), the point at which seed yield starts to decline, was identified as 54 mm. Beyond this threshold, seed yield dropped by 0.28% per mm, or roughly 1.2 kg/ha per mm. This means that on a warm summer day with a potential evapotranspiration (PET) of 4.5 mm, each day above the Dc could cost approx. $53/ha, assuming a seed price of $10/kg.

Importantly, this seed yield decline was consistent across seasons, regardless of when the drought occurred. This consistency suggests that how dry the soil gets is more important than when the drought happens (Figure 1B). While drought before flowering (pre-anthesis) often led to greater yield losses, this was likely due to higher daily PET during that developmental stage, which caused the soil to reach Dc faster—not because the crop was more sensitive to water stress at that time. Similar patterns have been observed in other crops like wheat, barley, and tall fescue (Huetting *et al.*, 2013; Jamieson *et al.*, 1995). A common rule of thumb is that Dc occurs when about 50% of the soil's available water has been used (Brown *et al.*, 2010). For Templeton silt loam soils with gravel layers below 65 cm, the available water content is approximately 120 mm (Lilburne *et al.*, 2012), suggesting the Dc would be about 60 mm.

During spring, grass seed crops require water to produce sufficient seed head numbers and to maintain green leaf area to maximise seed yield potential. In this study, seed number was identified as the principal component increasing seed yield (Figure 2). Comparable effects of spring irrigation on seed number and seed weight have been reported for perennial ryegrass and tall fescue, contributing to enhanced seed yields (Chastain *et al.*, 2015; Huetting *et al.*, 2013). Irrigation increased seed head density and the number of branches per head (data not shown), both of which are critical contributors to increasing seed number. Despite seed yield variability among seasons, the strong association between seed yield and seed number underscores the central role of seed number in determining yield potential.

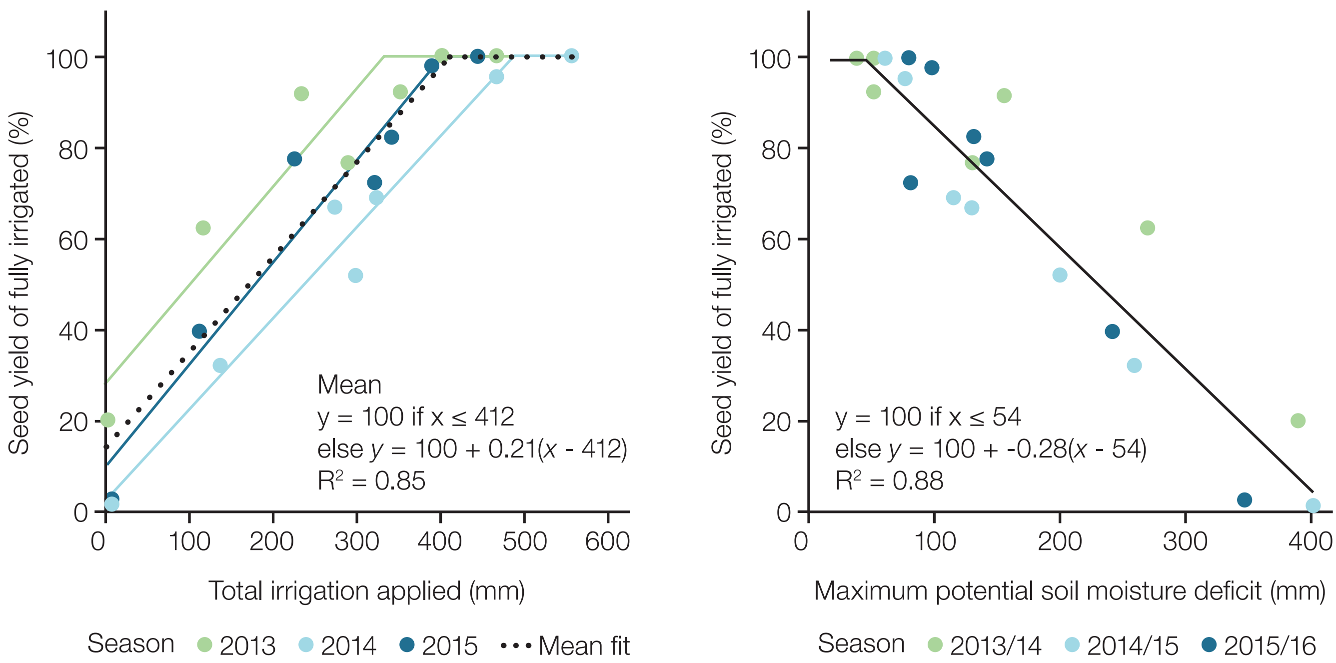

Figure 1.A. Normalised seed yield of browntop 'Arrowtown' following different irrigation treatments over three seasons and **1.B.** normalised seed yield response of 'Arrowtown' browntop following different drought intensities expressed as maximum potential soil moisture deficit when grown near Chertsey, Canterbury, New Zealand between 20013-14 and 2015-16. Breakpoint = 54 mm (± 14), Slope = -0.275 (±0.024) %/mm additional deficit, seed yield at 100% is 432 kg/ha, R^2 = 0.88.

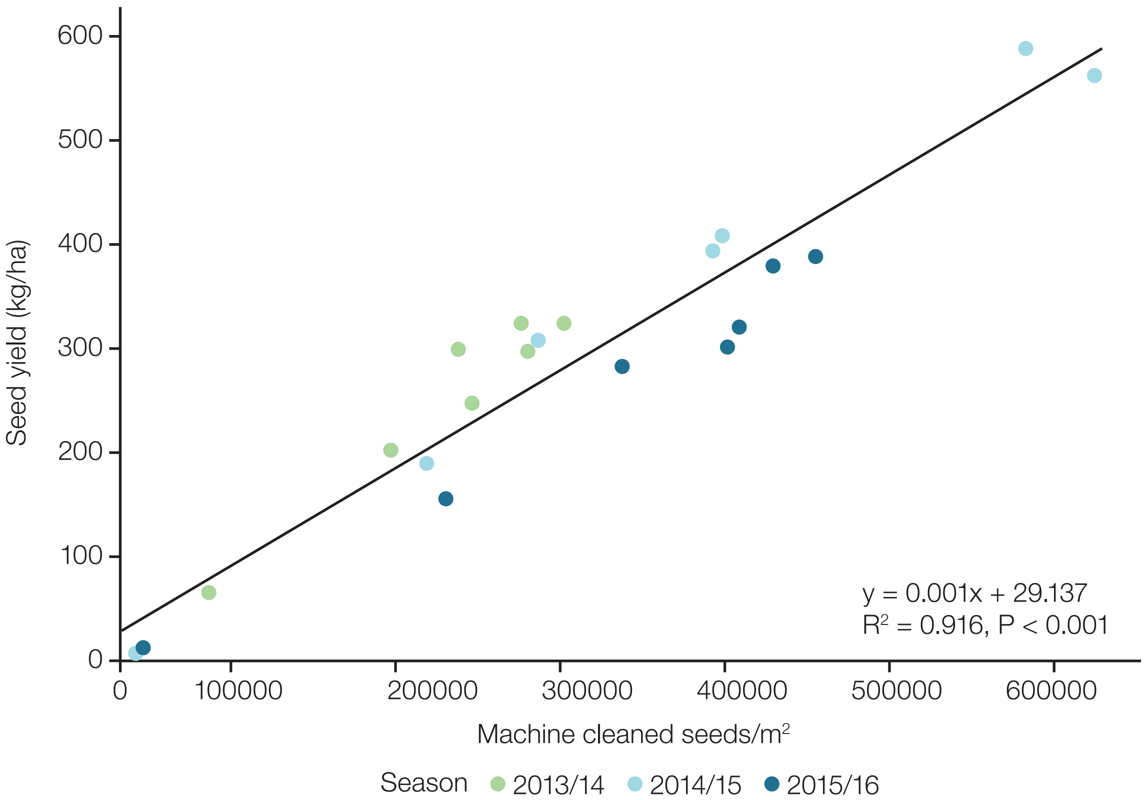

Figure 2. Seed yield response to the number of seeds per square metre for browntop 'Arrowtown' grown over three seasons and treated with different irrigation quantities near Chertsey, Canterbury, New Zealand between 2014 and 2016 harvest seasons (Pearson correlation coefficient r = 0.957, P<0.001).

Table 2. Seed yield of browntop 'Arrowtown' for three seasons following different irrigation treatments when grown near Chertsey, Canterbury, New Zealand between 2013-14 and 2015-16.

		2013-2014		2014-2015		2015-2016	
Trt. No.	**Treatment**	**Applied[1] (mm)**	**SY[2] (kg/ha)**	**Applied (mm)**	**SY (kg/ha)**	**Applied (mm)**	**SY (kg/ha)**
1	Nil	0	65	0	5	0	10
2	Replace 25% of ET	119	202	132	190	113	153
3	Replace 50% of ET	235	296	259	392	227	300
4	Replace ET (R-ET)	467	322	527	586	444	386
5	R-ET to anthesis f.b. 50% of R-ET	402	322	437	560	389	378
6	50% of R-ET to anthesis f.b. R-ET	292	247	309	406	-	-
7	75% of ET	351	298	-	-	-	-
8	25% ET until 1 Jan f.b. R-ET	-	-	291	307	-	-
9	R-ET to 1 Dec, f.b. 25% to 1 Feb, f.b. R-ET	-	-	-	-	321	279
10	R-ET to1 Jan f.b. 25 % of R-ET	-	-	-	-	340	319
	Mean		**250**		**349**		**261**
	P value		**<0.001**		**<0.001**		**<0.001**
	$LSD_{0.05}$		**69.9**		**45.5**		**49**
	CV (%)		**18.8**		**8.76**		**13**

Note: Yellow highlighted treatments are in the top statistical group. f.b. = followed by, [1] = applied irrigation, [2] SY = Seed yield.

Summary

Over three seasons, browntop seed yield increased with irrigation, peaking at around 412 mm. However, the ideal amount varied each year, ranging from 334 to 486 mm, depending on canopy size, seasonal rainfall and evapotranspiration. Seed yield consistently dropped once the critical soil moisture deficit (Dc) of 54 mm was exceeded, regardless of when drought occurred. This means browntop must be irrigated consistently throughout the season, especially when approaching Dc. On hot days with high water demand, delays in irrigation can quickly lead to yield losses. Larger losses seen before flowering were likely due to faster soil drying, not increased crop sensitivity.

References

Brown *et al.*, 2010; Chastain *et al.*, 2015; Guy *et al.*, 1990; Huetting *et al.*, 2013; Jamieson 1982; Jamieson *et al.*, 1995; Lilburne *et al.*, 2012; Rolston *et al.*, 1998; Seabold and Perktold, 2010.

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PO Box 23133, Hornby, Christchurch 8441, New Zealand
Phone: +64 3 345 5783 • Fax: +64 3 341 7061 • Email: far@far.org.nz • www.far.org.nz