



# Cocksfoot seed production

ISSUE  
16



SEED INDUSTRY RESEARCH CENTRE



- Establishment
- Management
- Diseases

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# FAR Focus 16

## Cocksfoot seed production

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# 1. Background



The information enclosed in this FAR Focus summarises 15 years of cocksfoot (*Dactylis glomerata*) research funded by the Foundation for Arable Research (FAR) and the Seed Industry Research Centre (SIRC) with support from the Cocksfoot Growers Association.

This FAR Focus outlines the key practises required to grow cocksfoot seed crops, covering topics such as crop establishment, nutrient requirements, crop management and harvesting. Topics outside the scope of this booklet include emissions profiles and off-farm considerations such as seed cleaning etc.

#### Key points summary:

- Cocksfoot is commonly sown at 4-6 kg/ha in 30-45 cm row spacings.
- Grassweeds, including wild oats, should be controlled as early as possible each year.
- Cocksfoot should be closed from grazing during June or early July, while earlier cultivars should be closed earlier.
- Two applications of plant growth regulators (PGR) such as Moddus® Evo (trinexepac-ethyl) and Cycocel® 750 (chlormequat chloride) should be applied between GS 32 and GS 37 to reduce lodging and shorten stems.
- Autumn nitrogen of approximately 50 kg N/ha should be applied to promote tillering. Spring nitrogen rates can be calculated by 165 kg N/ha – soil mineral N (0-60 cm soil depth).
- Irrigation scheduling requires an understanding of soil supply and crop water use. Irrigation should be applied to avoid water stress. The stress point commonly occurs when half the available water holding capacity has been removed.
- Fungicides that target the pathogens present should be applied in a preventative programme. Products that target rusts, leaf fleck and net blotch are unlikely to control downy mildew.
- Cocksfoot seed crops should be cut and threshed before seed loss occurs. Seed should be cooled following harvest and dried to a safe seed moisture content if required.

## 2. Establishment



### Key point:

- Cocksfoot is commonly sown at 4-6 kg/ha in 30-45 cm row spacings.

## 2.1 Background

Cocksfoot (*Dactylis glomerata*) can be certified for up to eight harvest seasons. Before sowing, consider levelling any uneven areas in the paddock, e.g. filling any wheel ruts etc to create a flat paddock to start. Cocksfoot has a small seed size (thousand seed weight 0.55-0.8 g) and is slower to establish than many other grasses, including grass weeds. Grass weeds, particularly ryegrasses (*Lolium spp.*) and wild oats (*Avena fatua*), should be actively controlled to reduce the soil seedbank for following crops. For further information see the weed control, Section 3.

Cocksfoot can be grown on a wide range of soils, but for seed production it is susceptible to drought stress so access to irrigation is advantageous on lighter soil types or areas prone to summer drought. Soils with a pH in the range of 5.8-6.2 are ideal for cocksfoot seed production, while moderate nutrient fertility (e.g. Olsen P 15-20, sulphate S 6-10, potassium QTK 6-8) is adequate where additional fertility can be applied as required in subsequent seasons.

## 2.2 Certification

The seed growing area must not have grown any other cocksfoot during the previous two harvest seasons. However, successive crops of the same variety and class may be grown on the same area without a time interval. Generally, isolation distances from other cocksfoot paddocks range from 50-100 m for crops larger than 2 hectares (ha) in size and crops can be eligible to be certified for up to eight years. For further information see <https://www.mpi.govt.nz/dmsdocument/115> or <https://www.asurequality.com/industries/seed-and-plant-health/seed-certification-bureau/>.

## 2.3 Pests

Slugs e.g. grey (*Deroceras reticulatum*) and brown field slug (*D. panormitanum*), and grass grub (*Costelytra zealandica*) larvae can cause plant loss during crop establishment. Monitor for slugs by placing tiles or sacks in the paddock during establishment, and control with molluscicides if required. For further information see Horrocks (2015) available from [https://assets.far.org.nz/uploads/FAR\\_Focus\\_12\\_-\\_IPM\\_-\\_Final.pdf](https://assets.far.org.nz/uploads/FAR_Focus_12_-_IPM_-_Final.pdf).

Monitor for grass grub larvae during the autumn and winter prior to establishment. This can be completed by digging spade squares and counting larvae. Treat or delay planting by a season as required. During establishment, grass grub larvae can remove cocksfoot plants by feeding on roots. Once established, cocksfoot plants are more tolerant of larval feeding than many other grasses. However, while plants may survive the feeding of grass grub larvae, they may not produce seed heads leading to patches of lower seed yield.

## 2.4 Sowing date and rate

Cocksfoot can be either 'undersown', beneath crops such as barley (*Hordeum vulgare*) and linseed (*Linum usitatissimum*) in the spring, or sown as a pure stand in either spring or autumn.

For spring sowing, a pure stand will not produce a seed crop in the first summer and thus any income will be via grazing or silage. Undersowing cocksfoot at a rate of 4-8 kg/ha, provides benefits of income from the cover crop while allowing cocksfoot plants time to establish. Larger cocksfoot plants are more likely to produce adequate seed heads during the first harvest season and are more tolerant of herbicides.

Autumn sowing should occur as a pure stand, as competition reduces tillering and delays tiller development in the first season. Autumn sowing should take place prior to mid-March on the lower Canterbury Plains and before mid-February on the upper Canterbury Plains, at a rate of 4-8 kg/ha. If sowing is delayed, sowing rates should be increased to ensure adequate tiller number in the first season. If sowing is delayed after mid-March, tillers may not be vernalised resulting in poor seed head numbers in the first year.

Both sowing times are commonly utilised and are commercially viable.

## 2.5 Row spacings

Row spacings of 30 cm have been popular since Brown *et al.* (1983) demonstrated that maximum seed yield was obtained from 30 cm row spacing when compared with 15, 45 and 60 cm spacings for 'Grasslands Wana'. This result was consistent for the first three consecutive harvests following autumn sowing. The mechanism of seed yield increase changed with row spacing, comparing 15 cm to 30 cm row spacings, the 30 cm spacing produced a larger number of seed heads and approximately 20% higher seed yields each season. When row spacing was increased to 45 and 60 cm, a larger number of seed heads were produced but these were unable to produce the same number of seeds/head. Presumably a result of intra-row competition leading to seed yield reductions of 15% at 45 cm and 30% at 60 cm when compared with the 30 cm row spacing.

## 2.6 Further reading

Brown, KR, Rolston, MP, and Archie, WJ (1983). 'Grasslands Wana' Cocksfoot Seed Production. Proceedings of the New Zealand Grassland Association, 44: 24-29.

Horrocks, A. (2015). Integrated pest management FAR Focus, Vol. 12. R. Craigie, and A. Heslop (Eds.), (pp. 32). Retrieved from [https://assets.far.org.nz/uploads/FAR\\_Focus\\_12\\_-\\_IPM\\_-\\_Final.pdf](https://assets.far.org.nz/uploads/FAR_Focus_12_-_IPM_-_Final.pdf)

# 3. Weed control



### Key point:

- Grassweeds, including wild oats, should be controlled as early as possible each year.

## 3.1 Background

Autumn- and winter-formed tillers are important in cocksfoot seed production as they form the majority of seed heads. Thus, if weed populations are high and interfere with autumn tillering, seed yield can be reduced. Therefore, adequate weed control is essential for producing the 700 seed heads/m<sup>2</sup> required to obtain high-yielding cocksfoot seed crops. Failure to control certain weeds e.g. wild oats, may lead to rejection from seed certification. Weed control includes the removal or topping of other nearby cocksfoot plants from fence lines, roadsides or laneways which could contribute to cross-pollination.

Herbicide products must be applied in accordance with their application instructions and should be applied in mix or sequence with products that contain a different mode of action to delay the development of on resistance.

## 3.2 Herbicide options

There are no pre-emergence herbicides registered for use in cocksfoot. A key first step is to select a clean field, if possible, a year before sowing. Actively reducing grass weed populations prior to planting increases the reliability of first year stands. Post plant, pre-emerge use of glyphosate (Group 9) is one method that provides a clean starting point at crop emergence. Nortron® (active ingredient (a.i.) 500 g/L ethofumesate, mode of action (MoA) Group 15) can be used at reduced rates, e.g. 2.0 L/ha, when applied pre-emerge of cocksfoot. However, Nortron® can reduce seed head number when applied post-emerge or at higher rates (Rolston, *et al.* 2019). If sowing is delayed past mid-February, Nortron® can reduce the established plant population.

Products such as terbuthylazine (Group 5) and flufenacet (Group 15) are unsuitable for pre-emergence use in new cocksfoot stands.

Cocksfoot requires 3-4 tillers to ensure crop safety for many post-emergence herbicides. For new stands, sow as early as possible when temperatures are warm to minimise the time to 3-4 tillers, then target weeds while they are small enough to achieve adequate control.

Few post-emergence herbicides are registered for use in cocksfoot seed crops. Broadleaf weeds can be controlled with a wide range of herbicides registered for use on other grass seed crops. Grass weed control is more difficult, but cocksfoot growers are commonly using:

- 5-7 g/ha metsulfuron (600 g/kg, group 2) on first year cocksfoot stands from the 3-4 leaf stage,
- 150-200 g/ha of Hussar® (a.i. 50 g/kg iodosulfuron, Group 2) to control annual poa (*Poa* spp.) and ryegrass weeds from the 4 tiller stage, generally applied in the late autumn. Hussar® is not effective against hairgrass (*Vulpia* spp.) and bromes (*Bromus* spp.) among others.

- Second-year cocksfoot crops are more tolerant of herbicides, providing more options for controlling weeds and volunteer cocksfoot seedlings. Products containing metsulfuron have good efficacy on broadleaf and some grass weeds. Products commonly applied to cocksfoot seed crops following the first harvest season include 1.5 L/ha of atrazine (500 g a.i./L, Group 5), with or without 1.5 kg/ha of diuron (900 g a.i./kg, Group 5). Additional options include prometryn, pyroxasulfone and flufenacet.

Between 2021 and 2024 trials investigated the crop safety of propyzamide (e.g. Kerb™ 500F, 500 g a.i./L propyzamide, Group 3). The 2022-23 and 2023-24 trials found no crop safety issues with propyzamide. This finding was in contrast to the 2021-22 trial (Rolston *et al.*, 2022). Rainfall in the 2022-23 and 2023-24 trials was high either during the application of the herbicide and/or in the days following, which may have protected the crop by washing the chemical from the leaves. The label for Kerb™ 500F recommends applying in temperatures <13°C while rain is falling, or shortly before rain is expected.

Phytotoxicity from propyzamide has been variable in trials, but generally no yield reductions have been seen at rates of approximately 1.0 L/ha of Kerb™ 500F and in some cases yield advantages are shown from controlling grass weeds and/or thinning of the crop (Table 3.1). Rates above 1.3 L/ha were associated with seed yield loss attributed to phytotoxicity in the 2021-22 season (Figure 1).

## 3.3 Interrow spraying

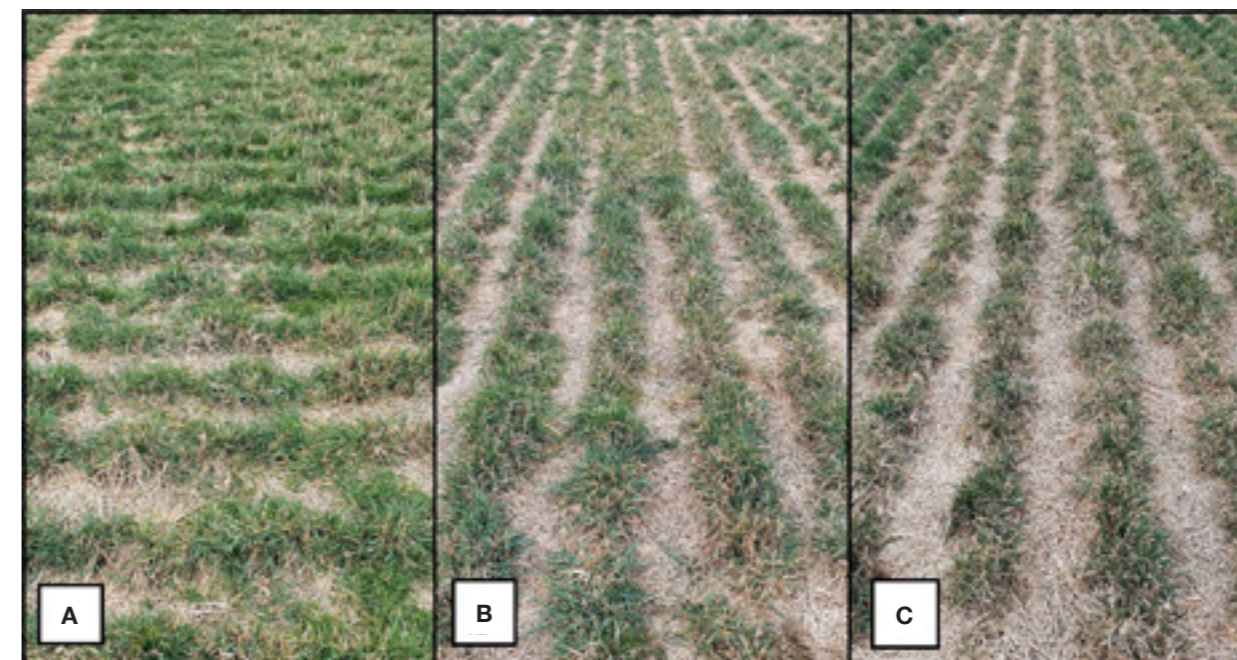
Interrow spraying can be a useful tool for reducing the incidence of difficult to control weeds in an area of the crop where crop competition is low. Interrow spraying allows for the use of non-selective herbicides e.g. glufosinate (e.g. Buster®, a.i. 200 g/L Glufosinate, Group 10), meaning grass weed control is more reliable, while spraying at an angle to drill rows allows for crop thinning in dense crops.

## 3.4 Wild oats

Wild oat control in cocksfoot seed crops can be difficult, particularly controlling late spring germinations in areas with bare ground. The application of Hussar® in late autumn can help suppress autumn germinating wild oats, however, escapes will need to be removed by hand rouging. The use of wild oat herbicides should be approached with caution; and where necessary they should be applied as early in the spring as possible. In three of four trials, Puma® S (a.i. 69 g/L fenoxaprop-P-ethyl, Group 1) and Stratos® (a.i. 200 g/L flamprop-M-isopropyl, Group 0) reduced cocksfoot seed yield by an average of 20%, despite any severe visual signs of phytotoxicity, when applied between September and October (Table 3.1). Thus, the decision to rogue or spray depends on the intensity of infestation. From commercial experience, earlier applications applied in July appear safer.

## 3.5 Genetic diversity

Three years of research between 2018-2021 investigated the tolerance of eight different cocksfoot cultivars to various herbicides. None of the trials were able to detect any cultivar-herbicide interaction. Therefore, the herbicide response was consistent among cultivars (Rolston *et al.*, 2019; Rolston & Chynoweth, 2020, Rolston & Chynoweth, 2020 2021).



**Figure 3.1.** Examples of cocksfoot (cv. Elise) phytotoxicity and biomass reduction as observed on the 26 August 2021 from propyzamide, applied as Kerb™ 500F (a.i. 500 g/L propyzamide) in July at either (a) untreated, (b) 1.15 L/ha or (c) 1.45 L/ha.

**Table 3.1.** Seed yield in cocksfoot grown near Methven in the 2021-22 and 2022-23 growing seasons following the application of nine herbicide programmes.

Treatment	Herbicide treatment, dose (L/ha) and date		Seed yield (kg/ha)	
	July	September	2021-22	2022-23
1	nil		863	917
2	Kerb™ 500F (0.70)		1080	961
3	Kerb™ 500F (0.85)		1075	1004
4	Kerb™ 500F (1.00)		949	1071
5	Kerb™ 500F (1.15)		988	1112
6	Kerb™ 500F (1.30)		889	1113
7	Kerb™ 500F (1.45)		683	952
8	Kerb™ 500F (0.85)	Puma® S (0.75)	699	672
9	Kerb™ 500F (0.85)	Stratos® (4.00)	872	614
P value			<0.001	<0.001
LSD (P=0.05)			169	141

Note: Kerb™ 500F (500 g a.i./L propyzamide, Group 3), Puma® S (a.i. 69 g/L fenoxaprop-P-ethyl, Group 1) applied with Hasten™ at 0.5 L/ha, Stratos® (a.i. 200 g/L flamprop-M-isopropyl, Group 0), Note: yellow highlights are equal to the top statistical group.

## 3.6 Post-harvest weed control

Little information on post-harvest grass weed control, including seed shed from the previous harvest, is available for cocksfoot seed crops. However, cocksfoot growers commonly use combinations of diuron, atrazine, prometryn, pyroxasulfone, and flufenacet. Be aware of grazing withholding periods before introducing livestock or cutting for silage, balage or hay.

## 3.7 Further reading

Rolston, P, and Chynoweth, R (2020). Herbicide tolerance of second-year cocksfoot cultivars. SIRC Research Results 2019/2020: 25-27.

Rolston, P, and Chynoweth, R (2021). Tolerance of second-year cocksfoot cultivars to different grass weed herbicide programmes. SIRC Research Results 2020-21.: 40-43.

Rolston, P, Vreugdenhil, S, and Chynoweth, R (2019). Herbicide tolerance of first year cocksfoot cultivars. FAR Research Results 2018/19: 88-91.

Rolston, P, Weith, S, and Gibson, O (2022). Evaluating the efficacy and selectivity of Group 3 propyzamide herbicide Kerb™ in cocksfoot. SIRC Research Report 2021-22.: 38-43.

# 4. Grazing and date of closing from grazing



## Key point:

- Cocksfoot should be closed from grazing during June or early July, while earlier cultivars should be closed earlier.

## 4.1 Background

It is generally accepted that cocksfoot seed heads are produced on tillers that form during the previous autumn. Tillers require the formation of basal roots before winter and green leaf area to determine daylength.

Initiation of seed heads takes place during spring in response to long/lengthening days. Seed head initiation is preceded by exposure to short days during the previous winter. Generally, cocksfoot cultivars require short days (less than about 11 hours) to fulfil vernalisation. Since daylength is perceived via the leaves, cocksfoot requires leaf area during winter and spring to complete this process.

Post-harvest management should aim to produce a new flush of autumn tillers that can be vernalised during winter and produce seed heads the following summer. It is vital to control the number of tillers, through grazing management or herbicides, as stands with more than 3000 tillers/m<sup>2</sup> may produce fewer seed heads than thinner stands. This is likely due to inter-tiller competition leading to lower individual tiller carbohydrate reserves.

Feeding by grass grub larvae can remove young roots during autumn and winter leading to tillers remaining vegetative.

## 4.2 Defoliation

Continual grazing via set stocking, or, to a lesser degree, rotational grazing, continually removes leaf area. The continual removal of leaf area allows light to reach the plant base. Light is required for the release of new tillers from buds found at the base of existing leaves. If buds have access to light, and enough reserves, they will grow out and form new tillers. Thus, appropriate grazing management can increase tiller density and potentially increase the number of seed heads at harvest. However, if the number of tillers becomes too large, inter-tiller competition can reduce the number of seed heads.

A two to four month period of zero grazing post-harvest provides tiller buds with access to the light they need to become new tillers, and for those tillers already present in the crop base to regrow. Subsequently, when all light has been captured by leaves, i.e. it's dark at the base of the crop, tiller production will stop. This 'break from grazing and tillering' allows for a build-up of carbohydrate reserves in the crown of cocksfoot plants, providing energy for regrowth following grazing and for reproductive development. At the same time, the dark phase at the plant base reduces tillering, ensuring that tiller numbers are optimal for seed production.

## 4.3 Seed yield response to closing date

Cocksfoot seed crops should be closed from grazing in June or July (Figure 4.1). Early cultivars likely require earlier closing than later cultivars so they can regrow green leaf area in order to sense daylength. Later defoliation (August) reduces the number of seed heads and therefore reduces seed yield.

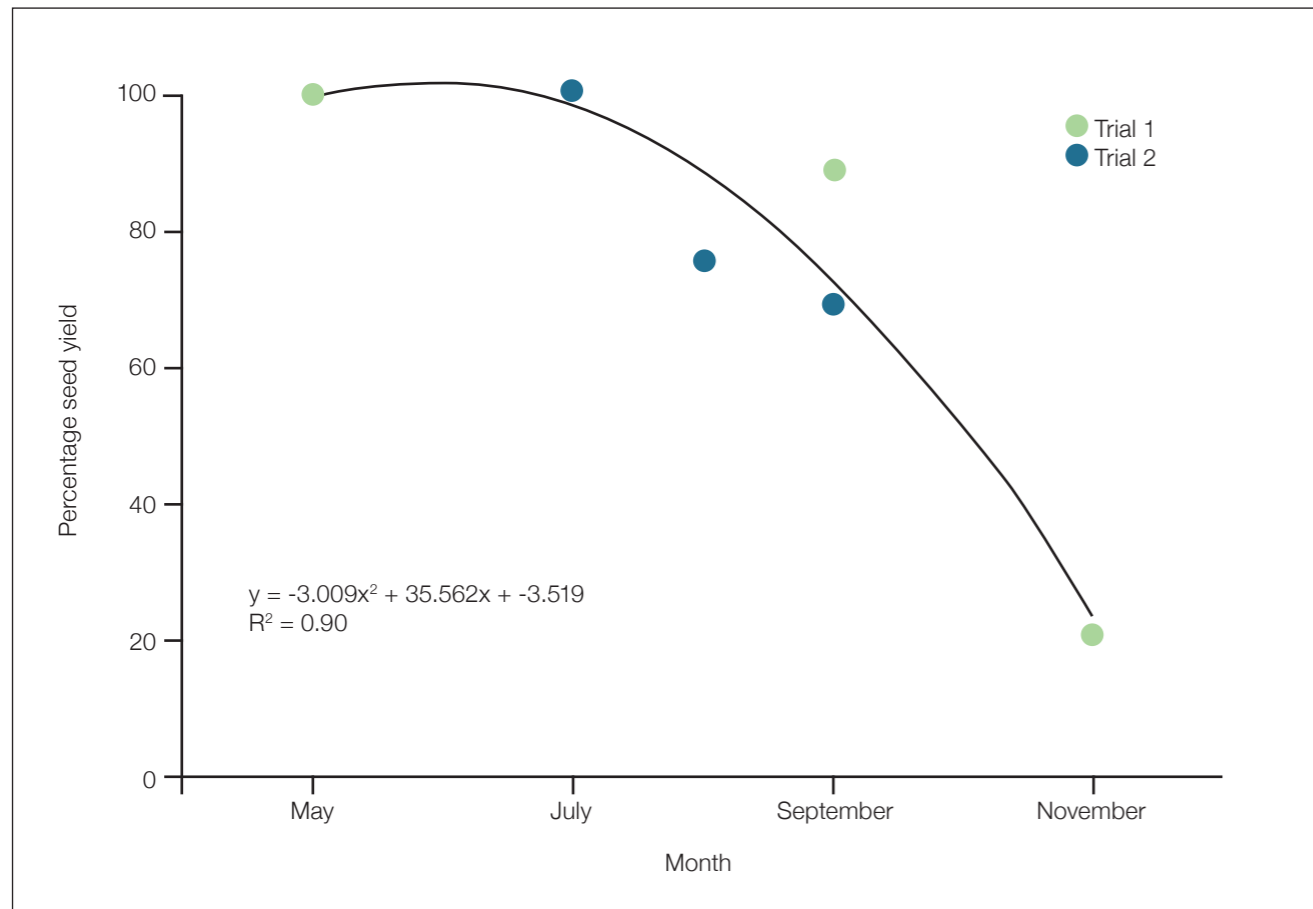
## 4.4 Removal of growing points

In cocksfoot, unlike ryegrass and cereals, you cannot monitor the growing point and continue grazing/mowing until the stem apex is vulnerable to removal. This is because in cocksfoot, the removal of leaf area in late winter and spring can lead to a reduction in the number of tillers that become reproductive.

## 4.5 Additional advantages of defoliation

Grazing removes excess and older leaf material which harbours disease that can move up through the leaf canopy during spring and summer.

# 5. Plant growth regulators



**Figure 4.1.** Cocksfoot seed yield from two trials expressed as a percentage of seed yield from the earliest closing date. Subsequent defoliation was completed using a tractor mounted 'finishing mower' to a height of approx. 10 cm. Trial 1 was completed in cultivar Kara in the 2012-13 season, trial 2 was completed with the cultivar Savvy in the 2016-17 growing season. Both trials were located near Methven.



### Key point:

- Two applications of PGRs such as Moddus® Evo (trinexapac-ethyl) and Cycocel® 750 (chlormequat chloride) should be applied between GS32 and GS37 to reduce lodging and shorten stems.

## 5.1 Background

Plant growth regulators (PGRs) are commonly used on cocksfoot seed crops to increase seed yield, a result associated with stem shortening and often, the absence of lodging. Commonly used PGRs such as Moddus® Evo (a.i. 250 g/L trinexapac-ethyl (TE)) and Cycocel® 750 (a.i. 750 g/L chlormequat chloride (CCC)) inhibit certain stages of the gibberellic acid (GA) pathway during stem extension. Gibberellic acid is a plant hormone responsible for the lengthening of stem internodes during the stem extension phase of crop development.

Since the 1990s, CCC (750 g ai/ha, 1 L/ha) has commonly been applied to cocksfoot seed crops as either single or split applications from beginning of stem elongation and potentially, again at 10-day intervals. These applications are aimed at preventing lodging and improving the ease of harvest through reductions in lodging and crop height. However, no increase in seed yield data was reported (Brown & Lill, 1990). In Oregon, USA, three studies with TE applied from 260 to 430 g TE/ha, applied at flag leaf to early head emergence, reported seed yield increases ranging between 6% and 19% (Gingrich & Mellbye, 2001; Gingrich & Mellbye, 2002). The use of two applications of TE plus CCC is now common practice in New Zealand (Table 5.1). In irrigated trials, the average seed yield increase has been 380 kg/ha or 68% greater than the untreated control (580 kg/ha compared with the average of all PGR treatments of 960 kg/ha). In contrast, the average seed yield response in the non-irrigated preliminary trials was 27%, even when moisture stress severely reduced seed yield (Rolston *et al.*, 2014).

**Table 5.1.** Cocksfoot seed yield (kg/ha) combined data for cultivars Savvy and Greenly II for PGRs applied in a split application at GS 32 (October 14) and GS 33-37 (November 1) at Chertsey, 2019.

PGR treatment and dose (L/ha) applied at both GS 32 and GS 33-37	Seed yield (kg/ha)	
	Dryland	Irrigated
Nil	315	630
Moddus® (0.4)	635	1060
Cycocel® (1.5)	690	1075
Moddus® + Cycocel® (0.4+1.5)	760	1345
Mean	600	1030
<b>P value</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
<b>LSD (P=0.05)</b>	<b>104</b>	<b>124</b>

Note: yellow highlights are equal to the top statistical group.

## 5.2 Timing

PGRs should be applied during stem extension with applications starting at growth stage (GS) 31-32 and finishing prior to booting (GS 45). Generally, the optimum timings for TE based applications range from GS 32-39 compared with GS 31-37 for CCC. Single applications should be applied earlier in the application window, particularly for TE, while split applications should span the GS range. In general, split applications between GS 31-32 and GS 37-39 have been more consistent at increasing cocksfoot seed yield and economic return, especially in irrigated crops. This result is likely driven by the large variation in GS between plants and tillers within cocksfoot seed crops.

The timing between GS 32 and GS 39 commonly spans ~20 days. Split applications allow for rates to be adjusted as the season unfolds. For example, rates can be reduced or the second application not applied if drought stress develops, or the application rates can be increased during seasons with high growth rates in high fertility and soil moisture conditions.

For information on determining growth stages see Stauss (1994) or [https://assets.far.org.nz/uploads/35448\\_FAR\\_ute\\_guide\\_-\\_cereal\\_growth\\_stages\\_\(3\).pdf](https://assets.far.org.nz/uploads/35448_FAR_ute_guide_-_cereal_growth_stages_(3).pdf)

## 5.3 Product and application rates

TE (100 g a.i./ha) or CCC (1500 g a.i./ha) applied once at GS 32, or in a double split, have often resulted in similar seed yield increases (Table 5.1). However, TE applied once at GS 37-39 can produce lower seed yields than single applications at GS 32 (Table 5.2). Generally, mixtures of CCC and TE (e.g. 750 + 100 g/ha) were more effective at improving cocksfoot seed yield than either CCC or TE applied alone (Table 5.1 and Table 5.2). CCC + TE (750 + 100 g ai/ha) applied at GS 31-32 and again at GS 37-39 resulted in the highest seed yield in five of the six field trials (Rolston *et al.*, 2014). This is in contrast with results from Oregon, USA where a single application of TE at GS 32 maximises seed yield (Anderson *et al.*, 2024).

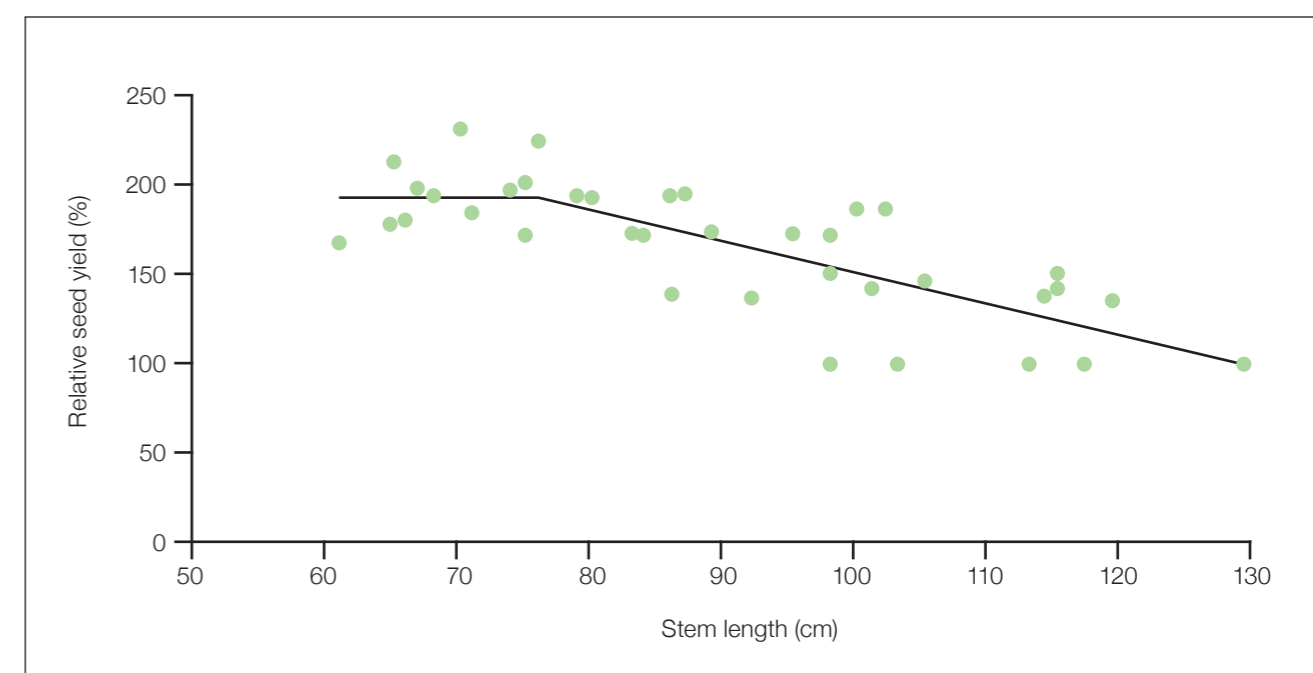
**Table 5.2.** Seed yield response, relative seed yield (RSY) and reproductive stem length of irrigated 'Safin' cocksfoot to different plant growth regulator treatments applied at GS 32 (13 October) and GS 37-39 (3 November 2011) grown near Ashburton in the 2011-12 growing season.

GS32		GS37-39		Seed yield (kg/ha)	RSY* (%)	Stem length (cm)
CCC*	TE*	CCC	TE			
0	0	0	0	440	100	98
1500	0	1500	0	770	172	95
0	200	0	0	860	193	86
0	0	0	200	600	136	92
750	100	0	0	760	171	84
750	200	0	0	1000	225	76
1500	100	0	0	870	196	74
1500	200	0	0	880	197	67
750	100	750	100	1030	231	70
1500	100	1500	100	940	212	65
0	0	750	200	870	195	87
0	0	1500	200	760	172	83
<b>LSD (P=0.05)</b>				<b>151</b>		<b>8</b>

Note: \* applied g a.i./ha; CCC, chlormequat chloride; GS, growth stage; LSD, least significant difference; RSY, relative seed yield; TE, trinexapac-ethyl. Note: yellow highlights are equal to the top statistical group.

## 5.4 Crop height

In all trials, stem shortening was associated with increased cocksfoot seed yield, even when lodging was not a significant factor. The untreated control plots often had a stem length of between 100 and 130 cm. During the responsive phase, the seed yield response averaged 12.5 kg seed/cm reduction in stem length. Thus, growers should aim to achieve a reproductive stem length of approximately 80 cm. Generally, no additional seed yield benefit was shown when stems were shortened to between 70–76 cm (Figure 5.1).



**Figure 5.1.** Effect of cocksfoot stem length on relative seed yield using a split line regression of the combined data from five plant growth regulator experiments located in Canterbury between 2009-10 and 2012-13 growing seasons.

## 5.5 PGRs and leaf burn

Two trials at Chertsey (2018-19 & 2019-20) attempted to evaluate the impact of leaf burn from PGR application on cocksfoot seed production (Harrison *et al.*, 2019; Rolston *et al.*, 2020). Only minor leaf burn was observed across two cultivars (Savvy & Greenly II) in two seasons, but large seed yield responses were observed (Figure 5.1). In a separate 2016-17 trial, severe leaf burn was observed from higher rate of PGR and major stem shortening (stunting) occurred, however, no seed yield depression was shown. Avoid tank-mixing PGRs with emulsifiable concentrate (EC) formulations of fungicides, as this can increase leaf burn.

## 5.6 Further reading

Anderson, N, Morad, M and Chastain, T (2024). Spring nitrogen and plant growth regulator effects on seed yield of orchardgrass. *Crop Science*, 1-8. <https://doi.org/10.1002/csc2.21349>

Brown, KR, and Lill, C (1990). Cocksfoot. NZGA: Research and Practice Series 5: 56-57.

Gingrich, G, and Mellbye, M. (2001). The effect of plant growth regulators on seed yields of grass crops. In W. C. Young (Ed.), 2000 Seed production research at Oregon State University USDA-ARS cooperating. Department of Crop and Soil Science Ext/CrS 115. (pp. 37-39). Corvallis, OR, Oregon State University.

Gingrich, G, and Mellbye, M. (2002). The effect of plant growth regulators on seed yields of tall fescue and orchardgrass. In W. C. Young (Ed.), 2001 Seed production research at Oregon State University USDA-ARS cooperating. Department of Crop and Soil Science Ext/CrS 121. (pp. 22-23). Corvallis, OR, Oregon State University.

Harrison, A, Chynoweth, R, and Rolston, P (2019). Cocksfoot response to plant growth regulators and effect of leaf burn on seed yield. *SIRC Research Results 2019/2020*: 31-34.

Rolston, P, Chynoweth, R, Kelly, M, McCloy, B, and Trethewey, J (2014). Seed yield response of four cocksfoot (*Dactylis glomerata* L.) cultivars following the application of stem shortening plant growth regulators. *New Zealand Journal of Agricultural Research*. doi:10.1080/00288233.2014.925942

Rolston, P, Vreugdenhil, S, and Chynoweth, R (2020). The effect of plant growth regulator-incited leaf-burn on seed yield in cocksfoot. *FAR Annual Research Results Booklet 2018/19*.

Stauss, R. (1994). Compendium of growth stage identification keys for mono- and dicotyledonous plants - Extended BBCH scale.: Ciba- Geigy AG.

# 6. Nutrition



### Key point:

- Autumn nitrogen of approx. 50 kg N/ha should be applied to promote tillering. Spring nitrogen can be calculated by 165 – soil mineral N (0-60 cm soil depth).

## 6.1 Background

In cocksfoot seed crops, autumn formed tillers produce the majority of the seed heads. Cocksfoot seed crops require a minimum of ~700 seed heads/m<sup>2</sup> to maximise seed yield.

## 6.2 Autumn nitrogen

Autumn applied nitrogen (N) is required to increase leaf area and encourage the release of new tillers. Tillers form from buds found in the base of last season's reproductive and vegetative tillers. Generally, an application of 40-50 kg N/ha is required in the autumn. However, an increased rate may

be required to maximise dry matter production if autumn and winter grazing is a priority. Less autumn N can be used if crops are well tillered or there are N reserves in the soil from previous crops.

In one trial investigating either 0, 40 or 80 kg N/ha (autumn applied), no difference in either head numbers or seed yield was recorded when followed by a standard spring N application of 120 kg N/ha.

## 6.3 Spring nitrogen

In five spring N trials carried out in Canterbury, the optimum N requirements were between 148 and 167 kg N/ha (Figure 6.1A), including soil mineral N measured to 60 cm soil depth. Data from two trials was influenced by lodging at higher N application rates (Figure 6.1B). When lodging was controlled via PGR application, the optimum N rates were approximately 20 kg N/ha higher (Figure 6.1A and Figure 6.1B).

The optimum spring N rates can be estimated as:

Spring N application rate (kg/ha) = 165 – soil mineral N (0-60 cm)

Assuming a soil mineral N of zero, the economically optimum application rates range from 136 – 150 kg of applied N. However, in these trials the soil mineral N averaged 42 kg N/ha, thus, the optimum applied N ranged from 106 – 125 kg/ha.

These New Zealand results are similar to those recorded in Oregon where in two of three trials, 100 lb N/ac, or ~112 kg N/ha, maximised seed yield, while in the third season no response to spring applied N was recorded (Anderson *et al.*, 2024). Data on soil nitrogen testing was not reported, but previous work has shown that due to Oregon's wet winters, their soil mineral N values are negligible.

Nitrogen should be applied to match crop demand, particularly in early spring. Applications should begin in August, when crop growth resumes following winter followed by one or two additional applications, so not to induce rapid growth and promote lodging.

## 6.4 Lodging considerations

Excess nitrogen was associated with crop lodging in two of the five nitrogen trials where 80-100 kg of applied N/ha maximised seed yield. Lodging was associated with yield depressions. Thus, nitrogen should be split throughout the spring at appropriate application rates so as not to induce lodging. Nitrogen application rates should be considered when developing a PGR program.

## 6.5 Seed head density

In the same trials, seed head density increased as N supply increased up to ~95 kg N/ha (Figure 6.2) or when ~50 kg N/ha was applied, following which seed head number was stable when additional N was applied.

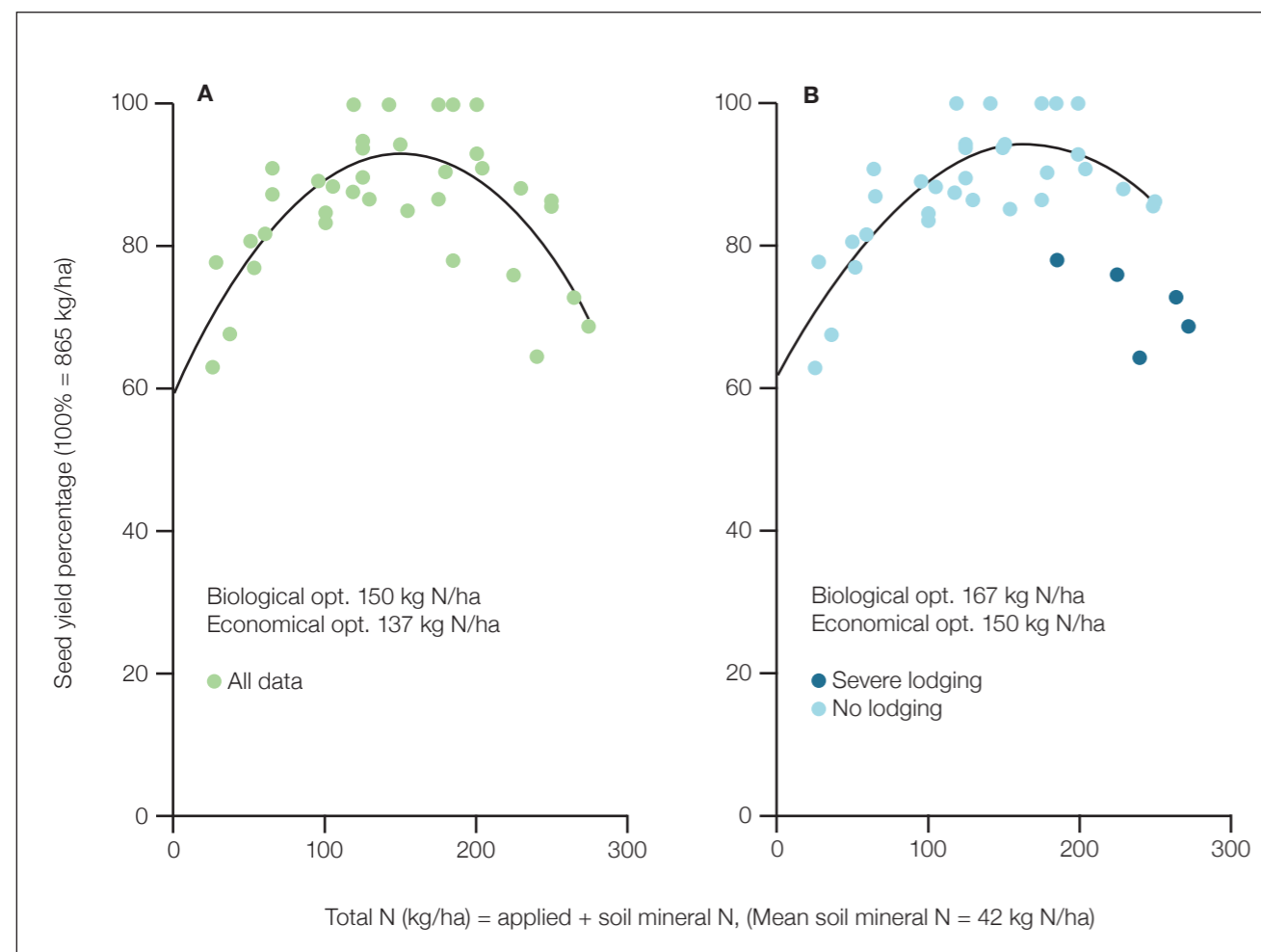
Thus, small amounts of N are required to encourage seed head production, with the remainder of the applied N influencing canopy expansion and duration. This is similar to results presented from Oregon where seed head density increased up to 112 kg N/ha (Anderson *et al.*, 2024).

## 6.6 Other nutrients

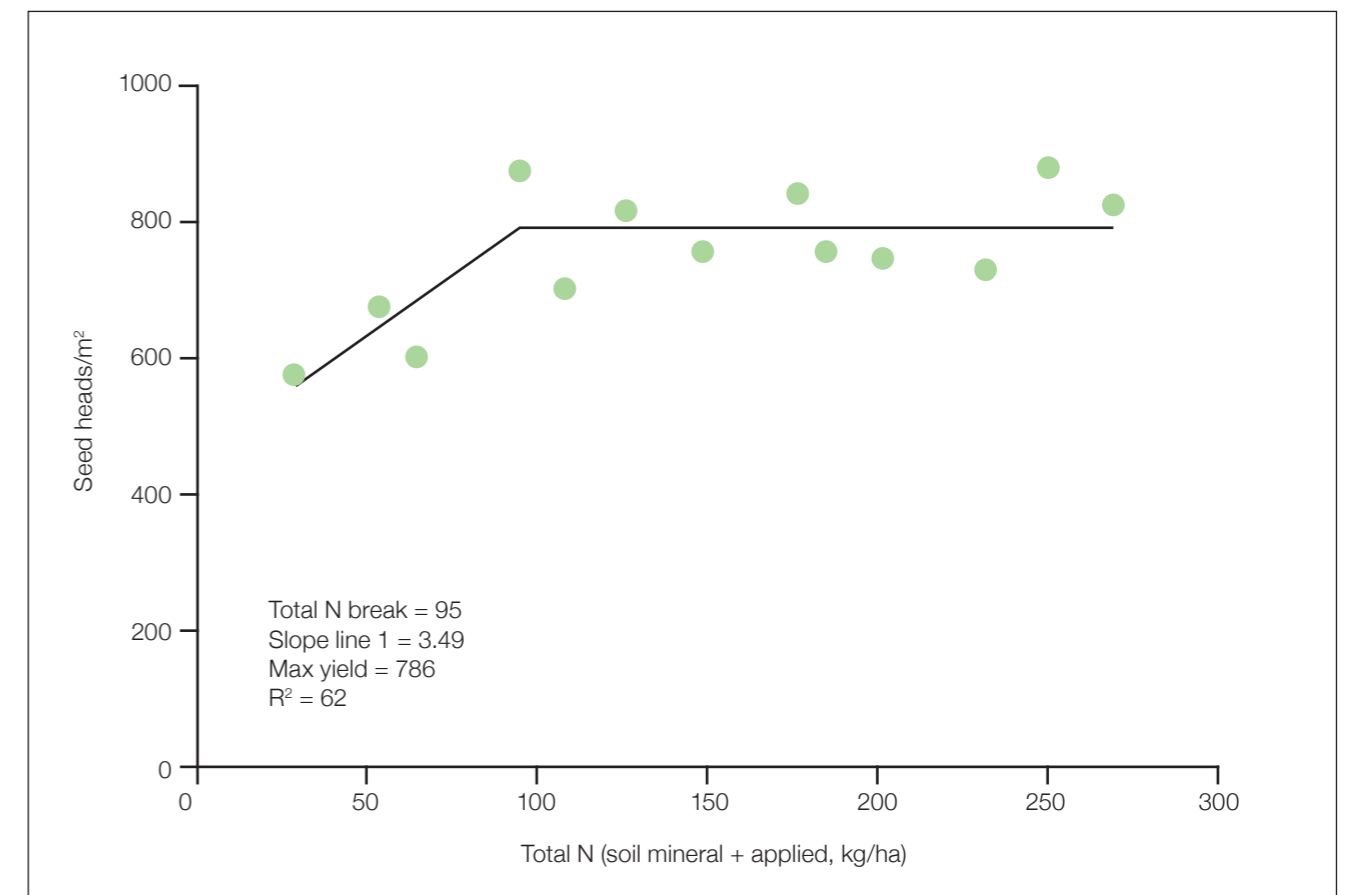
Maintenance rates of phosphorus (P), potassium (K) and sulphur (S) should be applied each season. For crops where straw is removed annually, losses of N and K from the system can be large, commonly in the range of 250 kg K/ha. Thus, when straw is removed for multiple seasons, deficiency can occur.

## 6.7 Further reading

Anderson, N, Morad, M and Chastain, T (2024). Spring nitrogen and plant growth regulator effects on seed yield of orchardgrass. *Crop Science*, 1-8. <https://doi.org/10.1002/csc2.21349>.



**Figure 6.1.** Seed yield of cocksfoot from five trials grown in Canterbury between 2013 and 2017, expressed as a percentage of the maximum yielding treatment (i.e. nitrogen was treated as the limiting factor) for a range of nitrogen treatments. Figure A presents a relationship for all data including, where lodging influenced seed yield. Figure B shows the relationship developed by excluding heavily lodged data (shown in red). Both the biological optimum and economical optimum are expressed as 'Total N' (the sum of applied and soil mineral measured to 60 cm). Biological optimum is the curve maximum, economical optimum was calculated using a seed price of \$5.25/kg and a nitrogen price of \$1.75/kg N.



**Figure 6.2.** Seed head number of cocksfoot following spring nitrogen (N) treatment. Data points are presented as the mean of five trials, averaged in 20 kg N/ha increments where total N includes the applied and soil mineral N measured from 0–60 cm. All trials grown in Canterbury, New Zealand between the 2019 and 2021 harvest seasons.

# 7. Irrigation management



## Key point:

- Irrigation scheduling requires an understanding of soil supply and crop water use. Irrigation should be applied to avoid water stress. The stress point commonly occurs when half the available water holding capacity has been removed.

## 7.1 Background

Plants require water to maintain photosynthesis and general plant structure. In normal growing conditions, plants consist of between 70-90% water. Water is absorbed via the root system and transpired into the atmosphere via leaf stomata. Adequate water is required to maintain open leaf stomata. Open stomata allow the uptake of carbon dioxide (CO<sub>2</sub>) which plants convert to carbohydrates via photosynthesis.

## 7.2 Soil supply

New Zealand soils have variable topsoil depth. On the Canterbury Plains the topsoil generally overlays gravel. The soil water holding capacity (the supply) is influenced by the texture and depth of topsoil. Concurrently, the rooting depth of the species being grown determines the usable depth of the soil. Thus, the water supply is determined by soil type and crop rooting depth. In general, cocksfoot has a deeper rooting depth than perennial ryegrass, thus has the potential to extract water from a greater depth. Plants extract water from the soil; as the soil dries water extraction becomes increasingly difficult and stress occurs. Water stress occurs before all the water has been extracted from the soil. In general, water stress, and the compromised of plant growth it brings, starts when soil water holding capacity drops to about 50 percent. For example, the soil type at the FAR Arable Research Site, located at Chertsey, is Templeton Silt Loam with ~60 cm of topsoil above free draining gravel (Lilburne *et al.*, 2012). The water holding capacity in the top 100 cm is ~125 mm, of which approximately half (62.5 mm) is freely plant available (assuming the crop explores 100 cm of the top soil). Thus, generally 62.5 mm of water use would represent a trigger point, or lower level, for irrigation management.

You can find information on water holding capacity at S-maps. A rough "rule of thumb" is each cm of topsoil holds about 1 mm of freely available soil moisture.

## 7.3 Demand

Evapotranspiration (ET) is the evaporation of water from the soil surface and plant leaves to the environment. Crop water use at any given time is determined by ET which, in turn, is determined by atmospheric demand for water. For example, when nor' west wind conditions prevail in Canterbury, water use is potentially large (~6 mm/day) due to hot windy low humidity conditions i.e. the atmosphere removes water from leaf stomata quickly. The potential ET for any given day can be calculated from daily weather data, making the following assumptions; that there is water available for crops use, that

the crop is actively growing and that the crop covers all of the soil surface.

Alternatively, ET calculations can be known as 'potential ET' or PET. In general, the larger canopies of seed crops lose 10-20 % more water via evaporation than those represented in the ET calculations; this is due to the formula's assumption that the crop is short and actively growing. Thus, after flag leaf emergence in grasses, the calculated PET values should be multiplied by 1.1-1.2 to reflect actual water use. In Canterbury, during spring and summer, the accumulated potential deficit (sum of daily ET minus rainfall) for many grass seed crops commonly exceeds 300 mm by harvest. Since many soils can supply 60-120 mm of water before water stress occurs, most crops are grown with a potential deficit of 120-180 mm.

Potential deficits are often larger than those presented as measured deficits. Measured deficits are expressed as the actual water extracted from the soil; and as extraction becomes more difficult as the soil dries, the actual water use decreases below the calculated potential. The decrease in water use is seen above ground as a change in colour, wilting and loss of green biomass.

Since cocksfoot transitions through reproductive development in a sequence of events that ultimately ends in tiller death at harvest, any stress that reduces the number or size of reproductive tillers and/or the duration of the green canopy leads to a reduction in seed production.

## 7.4 Cocksfoot seed yield responses to irrigation

Cocksfoot, cultivar Savvy, responses to water stress were investigated over three seasons near Chertsey, between the 2017-18 and 2020-21 seasons. The soil was a shallow 'Templeton silt loam' atop of gravels at ~60 cm. The soil supply was ~110 mm of water with an estimated stress point of ~60 mm. Water use was measured in the 0-30 cm layer at hourly intervals using Campbell Scientific CS650 soil reflectometers, and in the 20-60 cm layer weekly using a neutron probe. Irrigation was applied weekly to replace the measured water use (MWU), via a trickle tape irrigation system applying ~12 mm/hour. Treatments aimed to induce periods of drought either prior to, or following, flowering representing either spring or early summer drought.

In all seasons, the untreated controls achieved seed yields of ~600 kg/ha (Table 7.1) and measured soil water deficits were larger than 100 mm. Thus, the untreated crops removed 90% of the potentially available water from the soil.

Treatments that replaced MWU weekly achieved seed yields of ~1000 kg/ha with a maximum measured deficit of ~60 mm. Seed yield was reduced to ~700 kg/ha when soil water deficits of ~75-90 mm were measured, regardless of when the drought occurred.

When irrigation was applied to replace 50% of MWU weekly (deficit irrigation), cocksfoot seed yield was the same as alternative treatments that achieved similar measured deficits and the success of this method was determined by spring and summer rainfall. For example, in the 2020-21 season, the treatment supplying 50% of MWU achieved a seed yield the same as replacing the MWU when the maximum deficit was 71 mm. Thus, the soil was able to capture rainfall during

**Table 7.1.** Seed yield (kg/ha) of Cocksfoot, cultivar Savvy, over three seasons following seven spring irrigation treatments replacing measured water use (MWU) when grown near Chertsey, Canterbury, New Zealand between 2017-18 -2020-21 growing seasons.

Treatment	Year			Mean
	2017-18	2019-20	2020-21	
1. No irrigation*	674	603	575	617
2. Spring drought f.b. replace MWU	686	707	737	710
3. Replace MWU until early flowering	794	731	840	788
4. Replace MWU until early seed fill	682	815	936	811
5. Replace MWU until mid-seed fill	809	888	913	870
6. Replace MWU	996	958	1023	992
7. 50% of replace MWU	880	780	911	857
<b>Year mean</b>	<b>789</b>	<b>783</b>	<b>848</b>	
<b>P value</b>	<b>0.028</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	
<b>LSD (P=0.05)</b>	<b>202</b>	<b>110</b>	<b>136</b>	
<b>SE</b>	<b>68</b>	<b>36</b>	<b>46</b>	

Note: \*Soils returned to field capacity via rainfall each winter. Note: yellow highlights are equal to the top statistical group.

the growing season and the critical deficit was not reached. This contrasts with the 2019-20 season where seed yield was reduced by 22% when the deficit irrigation technique was unable to maintain adequate soil moisture to maximise seed yield.

## 7.5 Preventing crop water stress

Seed yield increases were primarily due to decreases in seed head density following spring drought (seen in treatments where <140 mm of irrigation was applied), followed by reductions in the number of seeds/head that reached a saleable weight. Following seed cleaning there was no difference in thousand seed weight between treatments (data not shown).

The results of this study demonstrate that producers need to understand the water supply of their soils and the critical deficit where seed yield decline begins. The subsequent application of irrigation should aim to maintain soil moisture levels above the critical deficit.

The critical deficit and seed yield loss for cocksfoot were similar to those of other grasses, suggesting that water extraction is similar between species when they have the same soil to explore. Similar results were shown for tall fescue (Huettig *et al.*, 2013) and perennial ryegrass (Chynoweth *et al.*, 2012) where late season drought reduced the number of seeds/m<sup>2</sup> that reached a saleable weight. Weekly irrigation rates can be reduced to 50% replacement of measured water use where soil moisture status is monitored and maintained above the stress point (~70 mm at this site). Alternatively, the period of time between applications could be extended if stress point is not reached. Thus, monitoring soil moisture status and acquiring an understanding of stress points are essential tools for irrigation scheduling. Monitoring soil moisture also

allows growers to avoid drainage from over application and gives an understanding of how rainfall is captured during the growing season.

## 7.6 Further reading

Chynoweth, RJ, Rolston, MP, and McCloy, BL (2012). Irrigation management of perennial ryegrass (*Lolium perenne*) seed crops. *Agronomy New Zealand*, 42: 77-85.

Huettig, KD, Chastain, TG, Garbacik, CJ, Young III, WC, and Wysocki, DJ (2013). Spring irrigation of tall fescue for seed production. *Field crops research*, 144: 297-304. doi:10.1016/j.fcr.2013.01.023

Lilburne, LR, Hewitt, AE, and Webb, TW (2012). Soil and informatics science combine to develop S-map: A new generation soil information system for New Zealand. *Geoderma*, 170: 232-238. doi:https://doi.org/10.1016/j.geoderma.2011.11.012

# 8. Common diseases of cocksfoot



**Key point:**

- Fungicides that target the pathogens present should be applied in a preventative programme. Products that target rusts, leaf fleck and net blotch are unlikely to control downy mildew.

A range of diseases can affect cocksfoot, and many of these are also found on other grass species such as ryegrass and tall fescue. For more in depth descriptions of all of the diseases highlighted in this section, please refer to the DISEASES OF COCKSFOOT: Identification and management in seed production handbook, compiled by Harvey & Braithwaite (2022) which can be found on FAR's website (<https://www.far.org.nz/resources/diseases-of-cocksfoot-identification-and-management-in-seed-production>).

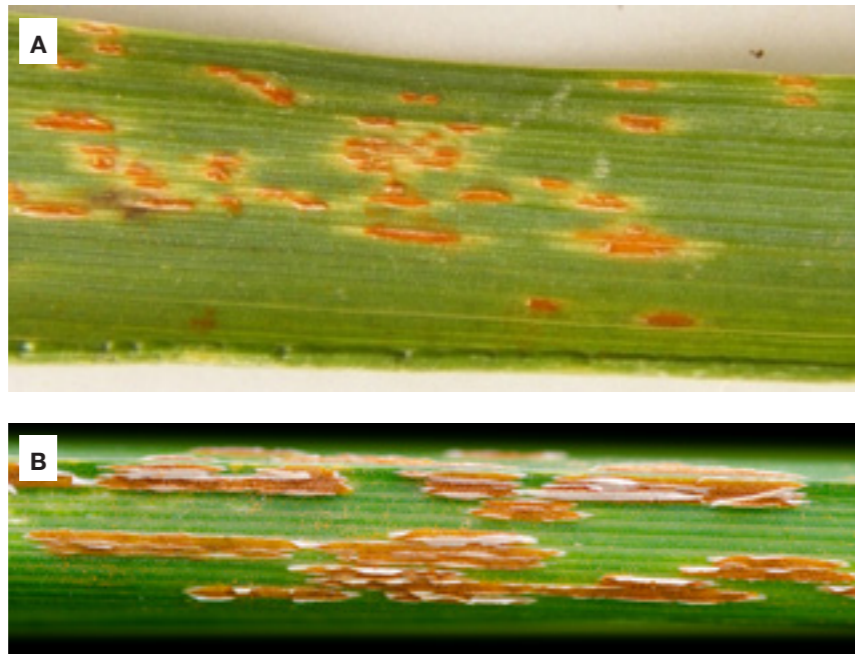
Fungicide products must be applied in accordance with their application instructions and should be mixed with products that contain a different mode of action to delay the development of fungicide resistance.

## 8.1 Rust diseases

Three main rust pathogens can affect cocksfoot seed crops; stem rust (caused by *Puccinia graminis*), leaf and stem rust (caused by *Uromyces dactylidis*, from here on referred to as leaf rust), and stripe rust (caused by *P. striiformoides*). Rust diseases have been shown to reduce cocksfoot seed yield.

### Stem rust

Stem rust can be identified by yellow to orange elongated, blistered, dusty pustules that appear mainly on the upper leaf surface (Figure 8.1A) and stem (Figure 8.1B). Over time the pustules will turn dark brown/black with the formation of teliospores.



**Figure 8.1.** Symptoms of stem rust, caused by *Puccinia graminis*, on the leaf (A) and stem (B) of cocksfoot.

### Leaf rust

Although the symptoms of leaf rust and stem rust can appear similar, leaf rust will have yellow to orange pustules which eventually turn black with the formation teliospores. Infected leaves die rapidly following disease appearance. Leaf rust can infect stems where symptoms express as circular blister-like uredia which form under the epidermis (Figure 8.2). These eventually rupture to release spores (Figure 8.2C).



**Figure 8.2.** Typical circular blister-like symptoms expressed by leaf and stem rust, caused by *Uromyces dactylidis*, on the leaf and stem of cocksfoot.

### Stripe rust

Compared with the other rusts described in this section, stripe rust is very rare, however, it is occasionally found on cocksfoot leaves. Stripe rust can be distinguished by the appearance of elongated lines of pustules that are produced between the leaf veins (Figure 8.3).



**Figure 8.3.** Typical stripe-like symptoms of stripe rust, caused by *Puccinia striiformoides*, on the leaf of cocksfoot.

### Control options

Although a wide range of fungicides control rust diseases in cocksfoot, as at September 2024, none of them have been registered for use in cocksfoot seed crops. FAR has collected a small amount of fungicide efficacy data relating to the control of rust diseases in cocksfoot (Table 8.1). In a 2010 trial, no foliar disease was observed. However, in a trial conducted in the following season (2011), leaf rust (*U. dactylidis*) and low levels of brown leaf spot (*Cercosporidium graminis*) were observed. When disease was controlled using a mixture of fungicide products, seed yield was increased by between 44% and 60% above the untreated control. Treatments with the highest seed yield included plots treated with DeMethylation Inhibitors (DMIs) (Group 3) fungicides including Proline® (a.i. 250 g/L prothioconazole) or a tank mix of a triazoles such as Folicur® SC (a.i. 430 g/L tebuconazole) or Opus® (a.i. 125 g/L epoxiconazole) and a Quinone outside Inhibitor (QoI; strobilurin) (Group 11) fungicide, such as AMISTAR® (a.i. 250 g/L azoxystrobin).

**Table 8.1.** Machine-dressed seed yield from two cocksfoot trials when treated with eight fungicide treatments grown near Methven in the 2009-10 and 2010-11 seasons.

Trt No.	Fungicide rates (mL/ha) and timing		Seed yield (kg/ha)	
	Early flower (GS 61) (3rd December 2010)	Late flower (GS 69) (23rd December 2010)	2010 cv. Greenly	2011 cv. Kara
1	Untreated	Untreated	840	360
2	440 mL/ha Folicur® SC	440 mL/ha Folicur® SC	860	450
3	400 mL/ha Proline®	400 mL/ha Proline®	820	540
4	500 mL/ha Opus®	500 mL/ha Opus®	820	450
5	600 mL/ha SEGURIS®Flexi	600 mL/ha SEGURIS®Flexi	830	470
6	440 mL/ha Folicur® SC + 500 mL/ha AMISTAR®	440 mL/ha Folicur® SC + 500 mL/ha AMISTAR®	900	520
7	500 mL/ha Opus® + 500 mL/ha AMISTAR®	500 mL/ha Opus® + 500 mL/ha AMISTAR®	920	520
8	400 mL/ha Proline® + 500 mL/ha AMISTAR®	400 mL/ha Proline® + 500 mL/ha AMISTAR®	880	600
Mean			860	490
LSD (P=0.05)			121	115
P value			NS	<0.01

Note: yellow highlights are equal to the top statistical group. Opus® (a.i. 125 g/L epoxiconazole, Group 3); Proline® (a.i. 250 g/L prothioconazole, Group 3); Amistar® (a.i. 250 g/L azoxystrobin, Group 11); Folicur® SC (a.i. 430 g/L tebuconazole, Group 3); Protek® (a.i. 500 g/litre Carbendazim, Group 1); SEGURIS®Flexi (a.i. 125 g/L isopyrazam, Group 7).

## 8.2 Leaf fleck disease

Leaf fleck, caused by the fungus *Mastigosporium rubricosum*, was previously considered a disease of minor importance in New Zealand. However, its prevalence has been increasing in recent years, particularly in older cocksfoot stands. Leaf fleck appears as numerous, small dark oval to diamond-shaped lesions on leaves (Figure 8.4). The associated leaf yellowing (chlorosis) develops around the infected areas with severely infected leaves senescing early. The pathogen over-winters on infected crop debris and releases spores that are spread by water splash and wind.

### Control options

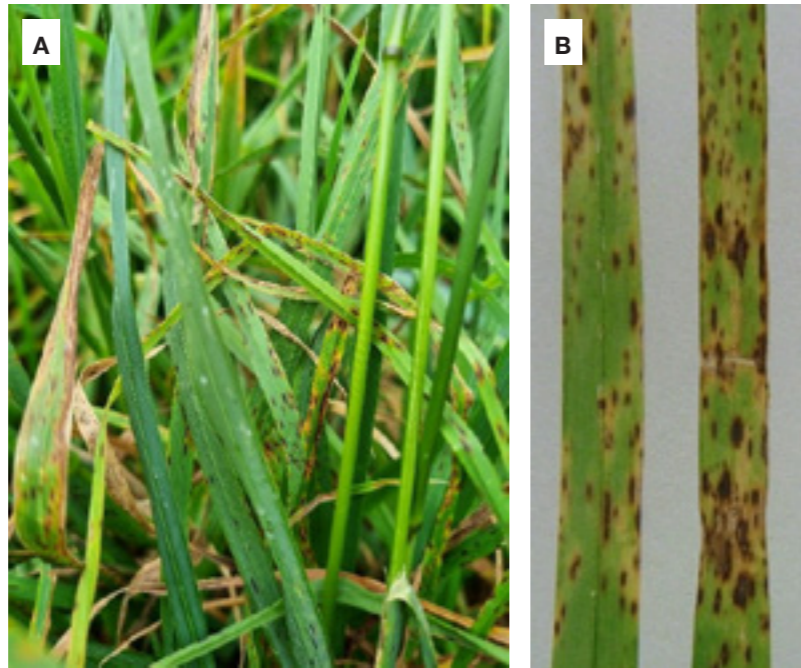
Trials have shown that various fungicides can control leaf fleck, but none are currently registered for this disease. However, fungicides used for rust control, such as DMIs (Group 3) including Proline® and Opus®, and the Succinate DeHydrogenase Inhibitors (SDHIs) (Group 7 fungicides) such as SEGURIS®Flexi (a.i. 125 g/L isopyrazam), are highly likely to be effective at suppressing leaf fleck. Trials from the 2022-23 season showed the importance of managing leaf fleck where in Methven it was the predominant disease present (Table 8.2). For more information see the commercial standard (treatment 2) in Table 8.2 in the downy mildew section (Section 8.4.).

## 8.3 Brown leaf spot

Brown leaf spot, caused by *Cercosporidium graminis* is a common leaf spot disease of cocksfoot, occurring in pastures and seed crops throughout New Zealand. Brown leaf spot will generally occur from mid-autumn until late spring. Symptoms commonly appear as long, streaky brown lesions with dark fruiting bodies (fascicles) and yellow margins (chlorosis) (Figure 8.5). Infected leaves senesce prematurely.

### Control options

See information under rust diseases, section 8.1.



**Figure 8.4.** Typical leaf fleck lesions, caused by the fungus *Mastigosporium rubricosum*, on the leaves of cocksfoot.



**Figure 8.5.** Typical brown leaf spot lesions with characteristic dark fruiting bodies on cocksfoot.

## 8.4 Downy mildew

Since the first reports in 2018, downy mildew has emerged as a major foliar disease of cocksfoot seed crops. The bleaching symptoms of downy mildew on seed heads can be confused with frost injury.

As at September 2024, the biotrophic oomycete *Sclerophthora cryophila* is considered the putative causal organism of this disease. This pathogen primarily infects susceptible cocksfoot plants via the leaves, leaf sheath and stems. The resulting damage causes noticeable head bleaching symptoms that are generally accompanied by significant yield losses (Jones, 1955; Chynoweth *et al.*, 2022; Harvey & Braithwaite, 2022; Chynoweth *et al.*, 2023). In cocksfoot, downy mildew presents as light yellow to tan lesions which can appear as bands on leaves and reproductive stems (Figure 8.6 A,B,C). Over time, these lesions expand, eventually causing the upper stem and seed heads to bleach (Figure 8.6D).

When temperatures are less than 15°C and leaves are wet, sporangia form in the stomata (Jones, 1955). These sporangia go on to release motile disease spores (zoospores). Spore dispersal occurs when conditions are conducive, generally under darkness when temperatures are cool and wet, which will infect neighbouring plants (Crouch *et al.*, 2022).

### Control options

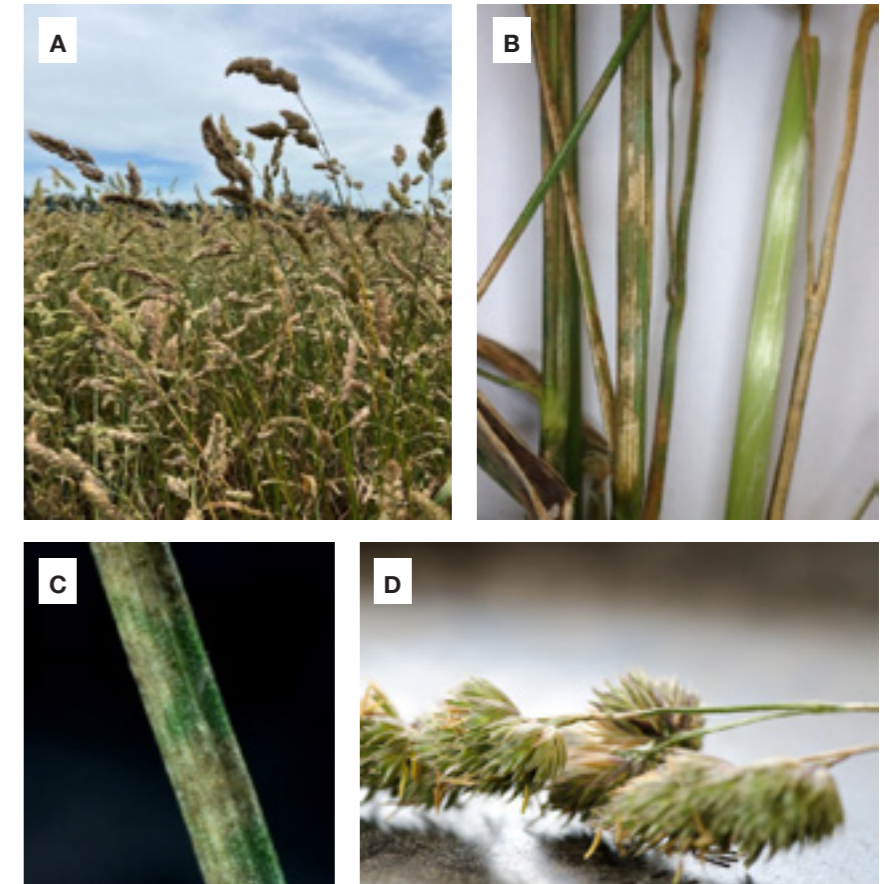
For detailed information on managing downy mildew in cocksfoot, refer to the DISEASES OF COCKSFOOT handbook compiled by Harvey & Braithwaite (2022).

Downy mildew is caused by an oomycete, a fungus-like organism. Therefore, many fungicides recommended for fungal pathogens e.g. those for the causal agents of leaf fleck, brown leaf spot and rust diseases, are not effective at controlling downy mildew.

From 2021-24, trials have identified products belonging to the Group 4 Fungicide mode of action groups, such as metalaxyl-M (e.g. Ridomil® Gold MZ WG), Group M4 Fungicides like folpet (e.g. Phoenix® Fungicide) and the Group P07 Fungicides such as phosphorous acid (e.g. Foschek®) can suppress downy mildew.

Seed yield data for plots treated with these fungicides applied across three separate growing seasons are shown in Table 8.2.

When used at the recommended label rates and appropriate timings, the use of fungicides to manage this disease have been reported to increase yield by up to or exceeding 300% in severe disease outbreaks (Harvey & Braithwaite, 2022). When creating a downy mildew management programme, always mix fungicides with different modes of action and ensure their activity will control both fungal and oomycete diseases. This strategy will help prolong the development of resistance by both fungi and oomycete pathogens.



**Figure 8.6.** Characteristic symptoms of downy mildew on infected tillers a) in the field, b) and c) on reproductive tillers and b) inflorescences of cocksfoot.

**Table 8.2.** Machine-dressed seed yield of cocksfoot following treatment with 12 fungicide programs for the control of downy mildew conducted across three separate growing seasons.

Trt No.	Fungicide rates (L/ha) and timing				Seed yield (kg/ha)		
	Timing 1 (T1) - 2nd PGR (GS33)	Timing 2 (T2) - Ear Emergence (GS59)	Timing 3 (T3) - Pre-Flowering	Timing 4 (T4) - Flowering (GS60-69)	Methven (22-23)	Wakanui (22-23)	Methven (23-24)
1	Untreated	Untreated	Untreated	Untreated	529	690	911
2	Commercial Standard	Commercial Standard	Commercial Standard	Commercial Standard	742 <sup>1</sup>	676 <sup>1</sup>	1260 <sup>2</sup>
3	Phoenix® (1.5 L/ha)	Phoenix® (1.5 L/ha)			777	711	1296
4		Phoenix® (1.5 L/ha)	Phoenix® (1.5 L/ha)		893	736	1244
5	Phoenix® (1.5 L/ha)	Phoenix® (1.5 L/ha)	Phoenix® (1.5 L/ha)		823	829	1352
6			Phoenix® (1.5 L/ha)	Phoenix® (1.5 L/ha)	726	692	1280
7		Ridomil®WG (2 kg/ha)	Ridomil®WG (2 kg/ha)		830	774	1139
8		Phoenix® (1.5 L/ha) + Ridomil® WG (2 kg/ha)	Phoenix® (1.5 L/ha) + Ridomil® WG (2 kg/ha)		800	812	1363
9			Phoenix® (1.5 L/ha) + Ridomil® WG (2 kg/ha)	Phoenix® (1.5 L/ha) + Ridomil® WG (2 kg/ha)	767	725	1337
10		Foschek® (5 L/ha)	Foschek® (5 L/ha)		792	849	1373
11		Curfew® (350 g/ha) + Dithane™ (210 g/ha)	Curfew® (350 g/ha) + Dithane™ (210 g/ha)		655	673	1242
12		Captan 600 Flo (4 L/ha)	Captan 600 Flo (4 L/ha)		-	-	1282
				<b>LSD (P=0.05)</b>	<b>206</b>	<b>137</b>	<b>167</b>
				<b>P value</b>	<b>&lt;0.05</b>	<b>&lt;0.05</b>	<b>&lt;0.001</b>

Commercial Standard Programs:

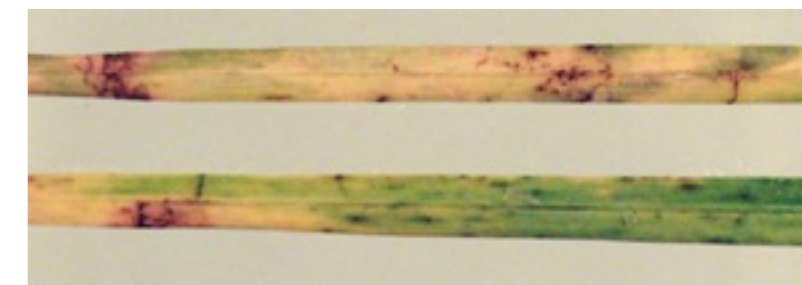
<sup>1</sup> T1, Opus® (1 L/ha) + AMISTAR® (0.75 L/ha); T2, Proline® (0.8 L/ha) + Comet® (0.8 L/ha); T3, Opus® (1 L/ha) + Comet® (0.8 L/ha).

<sup>2</sup> T1, Opus® (1 L/ha) + AMISTAR® (0.75 L/ha); T2, Proline® (0.8 L/ha) + SEGURIS®Flexi (0.6 L/ha); T3, Opus® (1 L/ha) + SEGURIS®Flexi (0.6 L/ha).

Note: yellow highlights are equal to the top statistical group. Amistar® (a.i. 250 g/L azoxystrobin, Group 11); Captan 600 Flo (a.i. 600 g/L captan, Group M4), Comet® (a.i. 250 g/L pyraclostrobin, Group 11); Curfew® (a.i. 450 g/kg cymoxanil, Group 27); Dithane™Rainshield™Neo Tec (a.i. 750 g/kg mancozeb, Group M3); Foschek® (a.i. 400 g/L phosphorous acid, Group P07); Opus® (a.i. 125 g/L epoxiconazole, Group 3); Phoenix®Fungicide (a.i. 500 g/L folpet, Group M4); Proline® (a.i. 250 g/L prothioconazole, Group 3); Ridomil®Gold MZ WG (a.i. 40 g/kg metalaxyl-M + 640 g/kg mancozeb, Group 4 Fungicide + Group M3).

## 8.5 Net blotch

Net blotch, caused by the fungus *Drechslera dictyoides*, affects grass seed species such as ryegrass, cocksfoot and tall fescue (*Festuca arundinacea*). Net blotch is commonly observed in autumn and winter, especially after rain events. Symptoms appear as a net of short, brown, linear lesions across the leaf blade that develop an extensive yellowing (chlorosis) up and down the leaf (Figure 8.7). Severely affected leaves die prematurely. The primary inoculum of net blotch is produced on old, necrotic leaves in the base of crops or from neighbouring stands or pastures. Spores (conidia) are wind and rain-splashed on to uninfected tissue. It's likely that net blotch can infect and be transmitted by seed.



**Figure 8.7.** Typical net blotch lesions on leaves of cocksfoot.

## Control options

One cocksfoot fungicide trial located near Ashburton during the 2009-10 growing season, had an outbreak of net blotch and a low level of scald (*Rhynchosporium orthosporum*). Fungicide application improved seed yield due to an increased green area (GLA) in plots infected with net blotch (Table 8.3).

**Table 8.3.** Treatments, fungicide rates and seed yield of seven different fungicide treatments applied in a cocksfoot fungicide trial conducted near Fairton during the 2009-2010 growing season.

Trt No.	Fungicide rates (L/ha) and timing	
	Flowering (GS 65) (3rd December 2010)	Seed yield (kg/ha)
1	Untreated	399
2	Opus® (0.5 L/ha)	410
3	Folicur® SC (0.44 L/ha)	413
4	Proline® (0.4 L/ha)	495
5	Proline® (0.8 L/ha)	441
6	Proline® (0.4 L/ha) + Protek® (0.5 L/ha)	405
7	Proline® (0.4 L/ha) + AMISTAR® (0.5 L/ha)	509
	<b>Mean</b>	<b>439</b>
	<b>LSD (P=0.05)</b>	<b>72</b>
	<b>P value</b>	<b>&lt;0.001</b>

Note: yellow highlights are equal to the top statistical group. Opus® (a.i. 125 g/L epoxiconazole, Group 3); Proline® (a.i. 250 g/L prothioconazole, Group 3); Amistar® (a.i. 250 g/L azoxystrobin, Group 11); Folicur® SC (a.i. 430 g/L tebuconazole, Group 3); Protek® (a.i. 500 g/litre Carbendazim, Group 1).

## 8.6 Scald

Scald, a fungal disease caused by *Rhynchosporium orthosporum*, is a minor disease in cocksfoot. Scald is a cool, moist weather disease primarily found in the South Island and southern North Island from April to October. Symptoms include irregular, light brown lesions on the leaves that can cover large areas (Figure 8.8). Spores (conidia) form on the leaf surface and are spread by wind or water splash. The fungus overwinters on old, dead leaves at the base of the plant.



Figure 8.8. Typical scald lesions caused on leaves of cocksfoot.

## Control options

See information under Net blotch (section 8.5).

## 8.7 Choke disease

Choke, caused by *Epichloe typhina* has not been recorded on cocksfoot in New Zealand. However, this is a disease that New Zealand growers should remain vigilant of. Choke has been recorded in New Zealand on Chewing fescue (*Festuca rubra subsp. commutata*), but this strain does not infect cocksfoot.

Choke disease is characterised by the formation of a white to creamy-yellow collar that encircles the flowering stem as it emerges in spring. The collar effectively 'chokes' the emerging seed head, interfering with seed head development and, in many cases the complete abortion seed heads on infect tillers.



Figure 8.9. Choke symptoms on cocksfoot, France 2023.

## 8.8 Further reading

Chynoweth, R, Weith, S, and Rolston, R (2022). Management of diseases in cocksfoot seed crops. SIRC Annual Research Report 2021/22.

Chynoweth, R, Weith, S, and Rolston, R (2023). Management of diseases in cocksfoot seed crops. SIRC Annual Research Report 2022/23.

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Harvey, IC, and Braithwaite, M. (2022). DISEASES of COCKSFOOT: Identification and management in seed production Retrieved from <https://www.far.org.nz/resources/diseases-of-cocksfoot-identification-and-management-in-seed-production>

Jones, W (1955). Downy mildew of *Dactylis glomerata* caused by *Sclerophthora cryophila*. Canadian Journal of Botany, 33 (4): 350-354. doi: 10.1139/655-030.

# 9. Harvest



### Key point:

- Cocksfoot seed crops should be cut and threshed before seed loss occurs. Seed should be cooled following harvest and dried to a safe seed moisture content if required.

## 9.1 Background

When a seed reaches physiological maturity, it stops feeding and has reached its final dry weight and size. Following physiological maturity, the seed moisture content (SMC) fluctuates in equilibrium with the relative humidity (RH) of the surrounding atmosphere. Generally, cocksfoot seed has a lower SMC than ryegrass seed at the same RH (Table 9.2). As individual seeds approach physiological maturity an abscission layer (weakened cells) may form, rendering the seed susceptible to shedding and loss from the plant.

There is large genetic variation among cultivars with many susceptible to seed shedding. In susceptible cultivars, seed losses can be large, particularly in windy conditions when seed is mature. Meanwhile, genetic variation in some other cultivars can make them difficult to thresh at harvest. Shedding losses can occur either while the crop is standing, prior to cutting, or within the cut row if weather conditions are extreme enough to move and shake the row. Growers should take all precautions to reduce the environmental impacts on seed loss. This includes cutting at an appropriate SMC, and may include cutting in the direction of the expected wind or undercutting the windrow to 'drop' the row below the height of the surrounding crop foliage.

Cocksfoot seed lines are likely to contain a number of 'doubles' (two seeds joined together) within the threshed seed sample. Doubles are handled differently between the International Seed Testing Association (ISTA) and Association of Official Seed Certifying Agencies (AOSCA) for seed purity standards. Thus, if concerned about doubles in a seed sample, consult with the contracting seed company to identify what constitutes an acceptable level.

## 9.2 Time of cutting

The progression from pollination to seed maturity is not uniform in grass seed crops and thus, a range of seed maturities exist within a single crop. Cutting at high SMC shortens the seed fill period leading to reduced seed size or weight, while cutting at low SMC can reduce seed yield as a result of seed shattering. Cocksfoot is ready to harvest when kernels have changed from being milky to doughy, but determining this in the field often requires a microscope.

SMC is the most reliable indicator of seed maturity and harvest timing in many grass seed crops. In Oregon, cocksfoot seed crops are commonly cut at 42-46% SMC (Silberstein *et al*, 2010). However, in cocksfoot, determining SMC is difficult due to the ratio of true seed to non-seed components e.g. glumes and other floral parts, usually found in seed samples. Thus, it is common for growers to have alternative indicators for harvest timing. For example, does seed shatter when rubbed in the palm of a hand, or shaken into a hat, or has the stem below the seed head changed colour? In seasons where crops have experienced drought stress or disease outbreaks colour change methods are difficult to use, as stems may have changed colour prematurely.

Generally, cocksfoot is cut via either windrowing or mowing and left to dry for a period of 5-14 days (depending on weather conditions) prior to combining. Cutting allows for the immature seed to dry within the cut row, while reducing the risk of more mature seeds being lost via shattering.

A harvest timing trial during the summer of 2018-19 evaluated three cutting dates and two pre-harvest descriptors in an attempt to find an objective method to define optimum cutting time. The pre-harvest descriptors were; (i) whole seed head moisture and (ii) seed rachis browning.

The highest seed yields were achieved when windrowing occurred at 29% seed head moisture content or when about three-quarters of the heads (72%) were  $\geq 50\%$  brown in the rachis, or when just under half (43%) of heads were  $\geq 90\%$  brown (Table 9.1, Figure 9.1) (Rolston *et al.*, 2019). Additionally, this was when a small amount of seed shatter occurred when walking through the crop and seed was easy to rub out by hand.



**Figure 9.1.** Rachis (seed head stem) of cocksfoot seed heads approaching harvest, with no browning (left) 50% browning (centre) or  $>90\%$  browning (right)

**Table 9.1.** Dates of windrowing and combine harvest, percentage of heads that were  $\geq 50$  and  $\geq 90\%$  brown, seed head moisture content (SMC) and machine dressed seed yield of cocksfoot, cultivar Savvy grown at Chertsey 2018-19.

Windrow	Harvest	SMC%	% heads $\geq 50\%$ brown	% heads $\geq 90\%$ brown	Seed yield (kg/ha)
11 Jan	22 Jan	41.3	28	5	830
15 Jan	22 Jan	29.0	72	43	1080
21 Jan	29 Jan	24.3	90	93	810
P value					<0.001
LSD (P=0.05)					63

Note: yellow highlights are equal to the top statistical group.

## 9.3 Direct combining

Since cocksfoot seed crops can stand well at harvest, direct harvesting is an option in environments where winds are light. One option is to lightly thresh the crop removing only the mature seed, thus creating a 'window with the combine', and return a few days later to re-thresh. However, low germinations can occur if SMC at harvest is above 30% and seed is not cooled and dried appropriately. Cocksfoot seed is susceptible to storage fungi with low germinations resulting quickly from poor storage. Seed is a living organism and must be treated as such.

## 9.4 Post-harvest and storage

Generally, cocksfoot is considered safe for storage at 11% SMC or 70% humidity (Hill, 1999b). On high temperature harvest days cocksfoot will benefit from cooling i.e. by blowing ambient air through the seed to remove field heat and assist in avoiding storage issues.

**Table 9.2.** Equilibrium moisture content of cocksfoot, ryegrass and barley for a range of relative humidities at 20-30°C, adapted from Hill (1999a).

Species	Seed moisture content at a range of different relative humidities								
	10	20	30	40	50	60	70	80	90
Cocksfoot	5.3	6.7	8.0	8.9	9.6	10.2	11	13.4	17.2
Ryegrass	5.8	7.2	8.6	10.4	10.9	12.6	13.8	14.9	18.3
Barley	5.8	6.8	8.4	9.3	10.7	12.1	14.0	18.8	19.5

Note: yellow highlights are equal to the top statistical group.

## 9.5 Further reading

Silberstein, T, Mellbye, M, Chastain, T, and Young III, W. Using Seed Moisture as a Harvest Management Tool. EM9012 Oregon State University. <https://extension.oregonstate.edu/sites/default/files/documents/em9012.pdf>

Hill, MJ. (1999a). The drying system. In M. J. Hill (Ed.), The drying and storage of grain and herbage seeds (pp. 23-68). Lincoln, New Zealand: Foundation for Arable Research.

Hill, MJ. (1999b). The storage environment and its control. In M. J. Hill (Ed.), The drying and storage of grain and herbage seeds. (pp. 69-91). Lincoln, New Zealand: Foundation for Arable Research.

Rolston, MP, Chynoweth, R, and Gunnarsson, M (2019). Optimising the time of harvest in cocksfoot. SIRC Annual Research Report 2018/2019: 13-14.

# 10. Acknowledgements

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