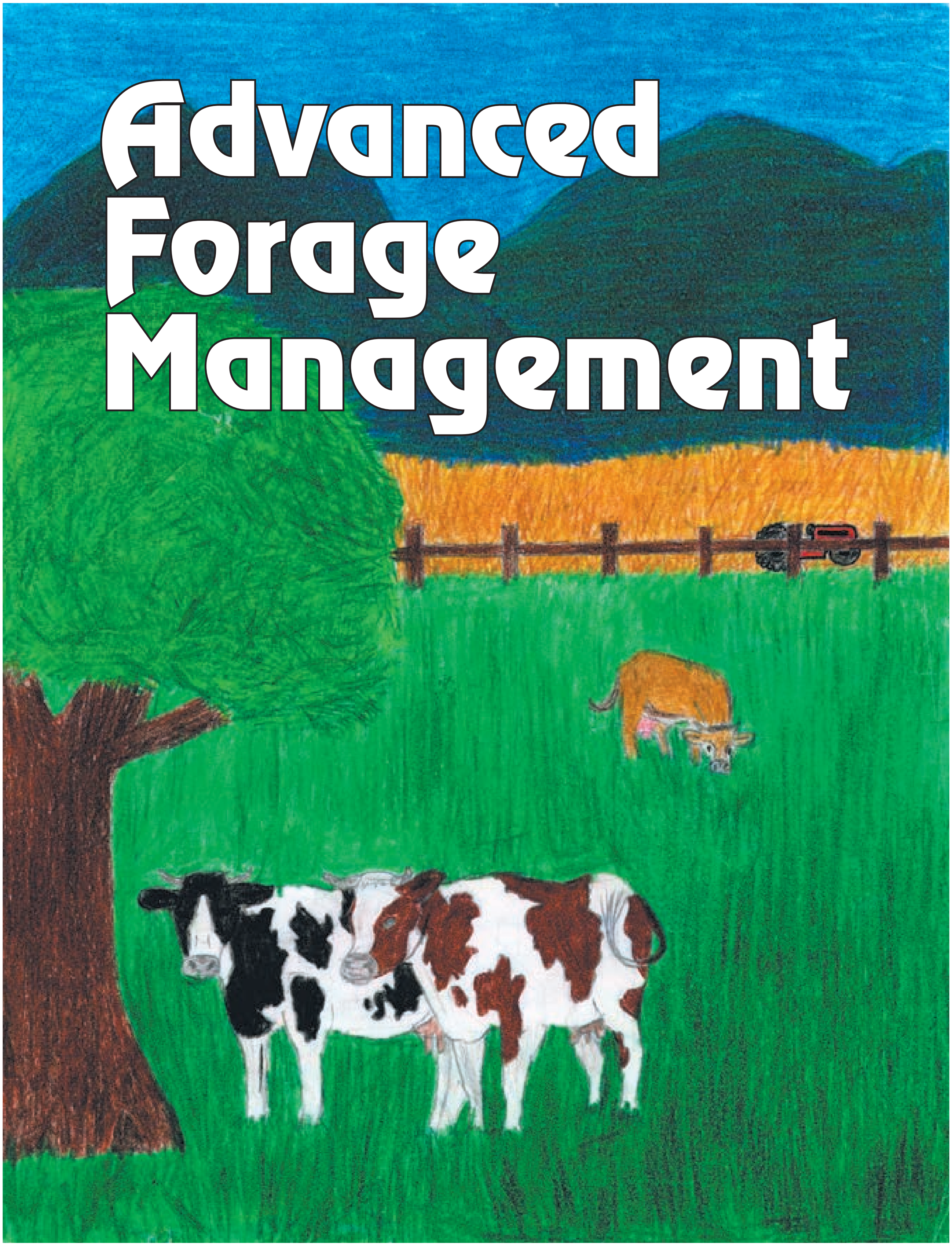
Advanced Forage Management



A production guide for coastal British Columbia and the Pacific Northwest

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Rise and Decline of Forage Stands

CHAPTER GUIDE

- Raising new forage stands
- Which forages maintain production best?
- Grasses and white clover
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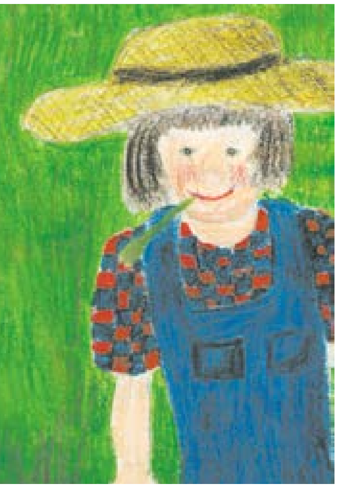
- Decline of forage stands-why it happens



Raising new forage stands

When you plant orchardgrass seed at 35 kg/ha (30 lb/ac), you are planting over 5000 viable seeds per square meter (500 seeds per sq. ft). With good seeding technique (firm seedbed, shallow seeding depth), warm soil and moisture, over 80% of these seeds typically emerge. However, within three years, 90% of the emerged plants die off while the surviving plants grow and occupy an increasing amount of space, a process referred to as self-thinning.

The seed of even improved and registered forage varieties is genetically variable. This is because the flowers of most forage species (both grasses and legumes) are fertilized by cross-pollination. The pollen of grasses is carried by wind and the pollen of legumes is carried by insect pollinators. Cross-pollination mixes the genes and creates genetic diversity.

In contrast, breeders can produce genetically uniform seed of most cereals because these crops self-pollinate. Corn seed is also genetically uniform because pollination can be easily controlled.

In the self-thinning process the hardiest individuals in the population (not necessarily the highest yielding) prevail. As some plants die off, survivors expand to fill the space. This process is gradual and almost invisible as dead plants are rarely seen!

When different forage species are sown together, those that produce vigorous seedlings generally dominate. Several forage grasses ranked in order of seedling vigour and seed size are listed in Table 1. *Note that the large-seeded grasses are not always the most vigorous*. However, small seed must be planted no deeper than 1 cm (0.5 in) whereas the larger seed will emerge from 2.5cm (1 in) depth.

Grasses differ from one another in how they expand to occupy available space. Tall bunchgrasses (explained in Ch. 1), such as orchardgrass, timothy and Matua prairiegrass, increase the size of individual plants by producing larger and more numerous tillers. Perennial ryegrass produces relatively small tillers but each plant can produce a great many tillers, resulting in very dense stands. Tetraploid varieties of both Italian and perennial ryegrass produce fewer but larger tillers than diploid varieties. Tall fescue plants spread by short underground stems, called rhizomes, gradually producing a dense sod. Quackgrass, smooth bromegrass and Kentucky bluegrass produce vigorous rhizomes that enable the plants to spread rapidly. White clover spreads by above-ground prostrate stems called stolons. *Note that the taller grasses can compensate for low plant density by producing very large tillers so that even relatively thin stands can sometimes produce high yields, provided that weeds are kept out*.

Table 1. A comparison of seed size and seedling vigour of several forage species.

SEEDLING VIGOUR	SEED SIZE	'000/kg ('000/lb)
Most Vigorous	**Largest**	
Italian ryegrass	Perennial ryegrass (Tetraploid)	290 (130)
Perennial ryegrass	Tall fescue	480 (220)
Orchardgrass	Perennial ryegrass (Diploid)	550 (250)
Timothy	Orchardgrass	990 (450)
Meadow fescue	Reed canarygrass	1,100 (500)
Tall fescue	Timothy	2,600 (1,200)
Reed canarygrass	Kentucky bluegrass	3,100 (1,400)
	Creeping bentgrass	7,000 (7,700)
Least Vigorous	**Smallest**	

Seeding with 'nurse' crops

A newly cultivated field is an ecological vacuum. The plants best adapted to invade are the fast-establishing annual weeds. These weeds can threaten the establishment of the more sluggish perennial forages. Before herbicides were widely available, farmers seeded perennial forages with faster-growing cereals, calling them 'nurse crops' because they kept weeds out. Although the cereals also compete with forage seedlings, cereals are more useful and manageable than weeds.

A study was conducted at PARC (Agassiz) to compare three methods of controlling weeds during establishment of orchardgrass and perennial ryegrass. The study compared barley and oat 'nurse' crops, herbicides and mowing.

The results showed that, under our moist maritime conditions, seeding with 'nurse' crops provided more forage and crude protein in the year of establishment than using herbicides or mowing (see Table 2). Indeed, there was no advantage to using herbicides for weed control and, of course, no herbicides are available for controlling annual grassy weeds in forage grasses (see Ch. 4). All establishment methods produced the same amount of forage in the second year. Note that seeding tall fescue with a 'nurse' crop may be risky because of the slow early growth of this grass.

Some farmers in the region have had success including a small amount of relatively short-lived perennial ryegrass (up to 20% of seed mix) as a 'nurse' crop for longer-lived orchardgrass and tall fescue. Sod-seeding perennial ryegrass in spring into fall-seeded orchardgrass or tall fescue has also been successful for some producers.

Table 2. Effect of establishment method on yield of perennial ryegrass and orchardgrass at PARC in south-coastal BC.

ESTABLISHMENT METHOD	YIELD (Dry Matter)	
	Establishment year	Second year
	t/ha (T/ac)	
Barley 'Nurse' crop	8.1 (3.6)	11.9 (5.4)
Oats 'Nurse' crop	8.0 (3.6)	11.9 (5.4)
Weedy	7.3 (3.1)	12.1 (5.5)
Herbicide	7.1 (3.1)	11.9 (5.4)

Which forages maintain production best?

Some locally grown forages can maintain their production for many years, even when density of the stand has declined somewhat. A study at PARC (Agassiz) compared production of new (1-3 year-old) and old (5-7 year-old) stands of several grass varieties in the same time period (1993-1995) (see Table 3). The study showed that for tall fescue, yield of old and new stands was equivalent. Yield of older stands of orchardgrass had declined by about 1.0 t/ha (0.5 T/ac.). Interestingly, the stand density of Hallmark orchardgrass had declined substantially due to infection by cocksfoot mottle virus (see below) but the yield decline was small. Few weeds had invaded the orchardgrass. Timothy and meadow bromegrass also maintained production well. Several grasses, most notably perennial ryegrass, yielded very poorly after three years.

Another study at PARC (Agassiz) showed that applying high doses of dairy slurry for several years reduced stand density of tall fescue. Nevertheless, yield of the heavily fertilized stands remained

Table 3. Comparison of yield of young (average of year 1-3) and old (average of year 5-7) stands of several grass species and cultivars grown in coastal BC in 1993-95. Note: where no values are shown, sward had greatly declined and yield was not measured.

Species	Cultivar	Annual Yield – Age of Stand: Young	Old	Difference
		(t dry matter /ha)[1]		
PERSISTENT GRASSES				
Orchardgrass	Hallmark	14.5	13.4	-1.1
Orchardgrass	Prairial	14.6	13.7	-0.9
Orchardgrass	Mobite	13.0	12.2	-0.8
Tall fescue	Johnstone	13.7	14.0	0.3
Meadow fescue	Bundi	10.9	10.2	-0.7
Timothy	Toro	14.9	14.0	-0.9
Meadow bromegrass	Regar	14.5	13.1	-1.4
NON-PERSISTENT GRASSES				
Prairiegrass	Grassland Matua	13.7	—	—
Reed canarygrass	Palaton	12.5	—	—
Perennial ryegrass (2N)[2]	Frances	11.4	—	—
Perennial ryegrass (4N)[2]	Bastion	10.9	—	—
Perennial ryegrass (4N)[2]	Condesa	10.9	—	—
Perennial ryegrass (2N)[2]	Melle	10.7	—	—
Sweet bromegrass	Deborah	—	—	—
Bromus sitchensis	Grassland Hakari	—	—	—
Smooth bromegrass	Manchar	—	—	—

[1] for T/ ac multiply by 0.45 [2] 2N= diploid, 4N= tetraploid

Figure 1. A trial to compare grasses at PARC (Agassiz) in south-coastal BC.

very high. These observations suggest that high rates of nutrient application increase size of individual plants, causing more competition for light and ultimately enhancing the self-thinning process.

Grasses with white clover

White clover and other legumes are often seeded with grasses because they contribute nitrogen through fixation and because of their high nutritional quality. The use of white clover in forage fields that have high nitrogen inputs has declined partly because the clover does not persist in the sward.

A study was conducted by PARC (Agassiz) to determine which grasses are most compatible in mixed stands with Ladino white clover (large type) under high inputs of nutrients. These stands received 375 kg/ha (350 lb/ac) of nitrogen annually.

The study showed that clover cannot compete with orchardgrass because of shading (see Table 4). Three varieties of orchardgrass were tested with similar results. White clover produced well when planted with the other grasses, especially with tall fescue, despite the large input of nitrogen. Some farmers are concerned that white clover competes aggressively with tall fescue causing the grass to die out. It is more likely that the clover invades patches with poor grass growth. The decline in white clover between 1990 and 1991 was due to severe winter conditions that also killed the perennial ryegrass (see ‘Winter injury,’ p.78).

An unexpected result in this study was that the grasses growing with the clover often looked more robust than the grass growing in a pure stand. Also, the overall yield of the mixtures was often greater than that of the pure stands. In recent years, peas and other annual legumes

Short-term and long-term productivity of forage grasses in coastal BC

Productivity of new stands

- Highest yielding grasses were timothy, orchardgrass (early and medium maturing varieties), and meadow bromegrass.
- Tall fescue, reed canarygrass and ‘Matua’ prairiegrass yielded 1 t/ha less than the top grasses.
- Perennial ryegrasses (both diploid and tetraploid) and meadow fescue yielded 3 t/ha less than the top grasses.
- Three of the grasses were invaded by weeds within the first 3 years.

Productivity of older stands

- Tall fescue maintained its production best; yield in years 5-7 equalled years 1-3.
- Yield of the other persistent grasses (orchardgrass, timothy, meadow bromegrass) declined by about 1 t/ha in the older stands.
- Several grasses did not persist past 3 harvest years due to winter kill and other factors, including perennial ryegrass, ‘Matua’ prairiegrass, and reed canarygrass. Less winterkill is expected near the coast.
- Meadow fescue had mediocre yield but excellent persistence.

Table 4. The proportion of clover harvested in heavily fertilized grass-clover mixtures at PARC (Agassiz).

Clover Harvested In Grass-clover Mixtures

	1989	1990	1991	1992
	% clover by dry weight			
Orchardgrass	1.9	1.6	1.4	0.3
Tall fescue	25.4	17.8	3.9	4.4
Timothy	10.3	18.4	2.1	2.8
Perennial ryegrass	20.7	31.6	—	—

have been shown to benefit cereal crops grown in rotation beyond their contribution of fixed nitrogen. Can this be a similar phenomenon?

Response of forage crops to irrigation

Forage production in coastal regions of BC and the Pacific Northwest is vulnerable to summer drought for two reasons. Abundant precipitation through much of the year and frequent high water tables limit rooting depth. Also, many of the best forage fields have coarse-textured soils that dry out quickly. For these reasons and the typical mid-summer drought in the region, farmers can expect to increase forage yield by 2-3 t dry matter/ ha (1-1.5 T/ac.) with summertime irrigation (see Table 5). Even greater response to irrigation can be expected in areas with particularly low summertime precipitation such as southern Vancouver Island.

Perennial ryegrass and timothy produce very poorly in mid-summer, particularly in dry conditions. These grasses have relatively shallow root systems. In contrast, orchardgrass and tall fescue have deeper roots and better summer growth. It is somewhat surprising that irrigation does not favour the shallow-rooted grasses more than the deep-rooted ones. The likely explanation is that summertime yield reduction in grasses is due to high temperatures as well as to water deficits.

Choosing between tall fescue and orchardgrass

The list on the next page compares tall fescue and orchardgrass and shows that both grasses have valuable attributes not found in the other. By using both species, farmers can diversify their forage crops thereby improving production and reducing risk.

Table 5. Effect of summertime irrigation on dry matter yield of several grass species at PARC (Agassiz) (1989-90).

SPECIES	VARIETY	NO IRRIG.	IRRIG.	INCREASE
		t/ha[1]		(%)
Orchardgrass	Hallmark	15.0	17.7	17.7
	Prairial	13.8	15.5	12.7
	Mobite	11.5	14.8	28.8
Tall fescue	Johnstone	13.4	16.4	22.4
Perennial ryegrass	Frances	10.0	11.7	17.1
	Melle	8.9	11.0	23.6
	Bastion	9.2	12.5	35.3
	Condesa	9.7	11.8	22.3
Timothy	Toro	13.2	16.3	24.0
Reed canarygrass	Palaton	10.5	13.3	27.3
Meadow brome	Regar	12.5	14.5	16.1

[1] For T/ac multiply by 0.45

Table 6. Comparison of Tall Fescue and Orchardgrass.

	Tall Fescue	Orchardgrass
SEEDLING		
Establishment	Slow	Moderate
Competitiveness with weeds	Poor	Moderate
Seeding rate	35-40 kg/ha	25-30 kg/ha
ADAPTATION		
Flooding	Good	Moderate
Drought	Good	Good
Winter hardiness (adapted varieties)	Very good	Good (var. Kay=superior)
Grazing suitability	Very good	Good
Sod strength for supporting traffic	Very good	Good
PERFORMANCE		
Yield	Up to 2 t/ha more than orchardgrass	
Maturity range of varieties	April 23 – May 10	May 7 – 28
Rate of drying or wilting	Very good	Good
Fall growth	Very good	Good
Persistence	Excellent	Good
DISEASE RESISTANCE		
Stripe rust	Resistant	Susceptible
Crown rust	Susceptible	Resistant
Leaf scald	Resistant	Susceptible
Cocksfoot mottle virus	Resistant	Susceptible
NUTRITIONAL QUALITY		
Milk yield	Very good	Very good
Feed Intake	Good-very good	Very good
Endophyte[1]	No[2]	No
Alkaloids[1]	Low[2]	No

[1] *See Fescue Endophyte Story in Chapter 7*
[2] *Registered seed of improved varieties*

Decline of forage stands—why it happens

After five or six years, self-thinning slows down and grass populations tend to become stable. However, many environmental stresses continue to act on the plant community so that stands may continue to deteriorate.

Frequent defoliation

Frequent defoliation reduces plant vigour and contributes to death of tillers. Table 6 compares the grazing tolerance of grasses. Orchardgrass withstands frequent clipping or grazing because it conserves root reserves and can regrow from cut tillers. Timothy is known to be susceptible to frequent clipping, especially during stem elongation, because it does not conserve nutrients and produces few new tiller buds during this growth stage.

The best strategy to withstand frequent clipping is to maintain growing points beneath the grazing height to ensure that they are not removed. In short grasses, like perennial ryegrass and Kentucky bluegrass, defoliation encourages tillering, which promotes a thick sod and high productivity. The thick sod maintains sufficient leaf cover for trapping sunlight even when the grass is grazed short. This approach would not work as well for taller species like timothy or orchardgrass with elevated growing points. Tall fescue is probably intermediate in this respect.

Table 6. Tiller death due to frequent defoliation.

	% tiller death
Orchardgrass	4
Tall fescue	16
Timothy	31

Perhaps related to this is the depth of rooting. Grasses with short leaves and rapid tillering tend to have shallow roots while tall and upright grasses have deeper roots. Short grasses such as perennial ryegrass, bluegrasses and fine-leafed fescues have dense roots near the soil surface. Many tall grasses with deeper roots survive and even grow through dry spells by drawing on water deep in the soil.

Figure 2. Severe winter conditions caused great stand losses in 1990–91.

Figure 3. Winter kill — variety differences.

Winter injury: learning from the winter of 1990-91

Winter conditions in the region are usually moderate so severe damage to forage varieties is unusual. In some years winter injury occurs but goes unnoticed because it results only in delayed spring growth that may be attributed to other factors. However, in the winter of 1990-91, forage crops all over coastal BC and Northwest Washington were decimated. Less damage occurred near the coast.

What causes winter-injury to plants? Low temperature is not the only factor. For example, alfalfa is likely to persist longer near Winnipeg or Saskatoon than it does in this region. Wet soils, high water table, frost heaving, desiccation, lack of hardening and disease interplay with low temperature to cause injury.

In the winter of 1990-91, a combination of circumstances contributed to the devastating losses. Rainfall in November was nearly three times average and temperature was above normal. Both factors delayed cold hardening. In December, temperatures fell sharply on two occasions with little snow cover at the time:

I.	*Dec. 17*	*11°C (52°F)*
	Dec. 18	*3°C (37°F)*
	Dec. 19	*-12°C (10°F)*
II.	*Dec. 27*	*7.5°C (46°F)*
	Dec. 28	*-14.5°C (6°F)*

Table 7. Effect of summertime irrigation on yield of grasses in fall 1990 and after severe winter conditions in spring 1991 at PARC (Agassiz).

	DRY MATTER YIELD			
	OCTOBER 1990		MAY 1991	
GRASS	*Prev. Non-Irrig.*	*Prev. Irrig.*	*Prev. Non Irrig.*	*Prev. Irrig.*
ORCHARDGRASS	*t/ ha[1]*			
Hallmark	2.1	3.1	3.1	0.66
Mobite	1.1	2.2	1.1	0.17
Prairial	2.2	2.9	0.8	0.14
OTHER GRASSES				
Timothy (Toro)	1.8	2.3	3.7	3.4
Tall fescue (Johnstone)	2.0	3.4	2.2	1.5
Meadow brome (Regar)	1.6	1.9	2.9	2.6
Reed canarygrass (Palaton)	1.3	1.7	2.2	2.4

[1] For T/ac divide by 2.

In early January, crops were subjected to severe desiccation for nine successive days when conditions were clear, cold and windy.

These winter conditions decimated stands of perennial ryegrass, Italian ryegrass, winter wheat and white clover. Timothy, fall rye and tall fescue generally survived with little injury. Survival of orchardgrass was more variable. Fall application of nitrogen increased damage and late-maturing varieties were generally less hardy than early-maturing ones.

Table 8. Persistence of an early and late variety of orchardgrass grown alone or together at PARC (Agassiz). In the mixed stand, each variety was seeded alternately in closely spaced double rows.

	DATE OF FIRST HARVEST	
	Early May	*Mid May*
	% cover	
Pure stand		
Hallmark (early)	100	100
Mobite (late)	100	100
Mixed stand		
Hallmark (early)	72	81
Mobite (late)	28	19

A study at PARC (Agassiz) showed that irrigating orchardgrass in July and August of 1990 increased winter injury and decreased spring growth in 1991 (See Table 7). In fact, irrigated orchardgrass varieties generally did not recover from the winter damage whereas unirrigated varieties did. This finding was very surprising given the long and wet interval between the irrigation events and winter and suggests that preconditioning of plants to winter occurs earlier than might be expected. Irrigation had only a slight effect on tall fescue and no effect on timothy, meadow bromegrass and reed canarygrass, all noted for being very winter-hardy.

Competition

As discussed above, competition occurs among plants of the same species so that the stronger plants occupy increasingly more space at the expense of weaker plants in a process referred to as self-thinning. According to Darwin, competition among similar individuals of the same species is more intense than among individuals of different species. Indeed, new species with different ecological niches

Figure 4. Sumas Prairie under water in November, 1990. High water table and flooding are especially damaging to orchardgrass.

evolve to reduce direct competition. Normally, competition among individuals of a single species goes unnoticed.

A study was conducted at PARC (Agassiz) to evaluate the effects of competition between an early and late cultivar of orchardgrass (see Table 8). The cultivars were seeded alternately in double rows spaced 10 cm (4 in) apart so that they could easily be distinguished. The varieties could also be identified by colour differences.

Three years after planting, the pure stands of both varieties were complete. However, in the mixed stand, the early-maturing variety prevailed over the late-maturing one probably due to early season shading. This effect was more pronounced with late than with early harvest.

This study revealed aggressive competition among varieties of the same species. Evidently, it is easier to maintain grass populations in pure stands than in mixtures. Interestingly, although the variety Mobite declined dramatically in the mixed stand, dead plants were rarely seen.

Disease — Cocksfoot Mottle Virus (CMV)

Cocksfoot mottle virus (CMV) infects orchardgrass and is well known in many regions around the world that produce orchardgrass. In Japan, CMV is considered the most serious disease of orchardgrass. PARC scientists first positively identified this virus on farm fields in BC about eight years ago. CMV is probably widespread in both coastal BC and the Pacific Northwest.

The disease is most easily noticed in late March or early April when plants are

Soil aeration reduces compaction in UK pastures[1]

Soil compaction is inevitable in high rainfall areas on farms with relatively fine-textured soils. These are soils with a high clay or silt content. Grazing by dairy cows on wet soils causes hoof imprints (called poaching) which reduce water movement through the soil. Tire tracks caused by heavy equipment have a similar effect.

Scientists at the Department of Agriculture of University College of Wales have studied the effect of slitting compacted soil with a soil aerator. The soils studied had a compacted layer at about 10-12 cm (4-5 in). The aerator had 15-cm (6 in) long tines. The fields were 20-year old pastures of perennial ryegrass.

The scientists found that penetrating the compacted layer of soil with the aerator could double forage production and nutrient uptake. They concluded that the field used in their study was more compacted than average but that the effect was so great that even fields with less compaction would benefit.

Ploughing also reduces compaction, but ploughing is expensive, takes land out of production for a period and tends to bring up stones. And the benefits of ploughing may be quite short term. Research is being conducted at PARC (Agassiz) to use soil aeration to improve manure absorption into grass fields and to reduce runoff from sloped land.

[1] based on Davies et al. in *J. Agric. Sci.* (Camb.) 113:189-197

Commercial aerating implement.

Table 9. Effect of slitting (aerating) compacted silty loam on yield and nutrient uptake by a perennial ryegrass sward in the UK.

	Control	Aerated
	kg/ha (lb/ac)	
Daily Growth	25 (22)	54 (49)
Daily N uptake	1.3 (1.2)	2.6 (2.3)

Fig. 5. Cocksfoot mottle virus attacks scattered orchardgrass, causing the stand to thin.

less than 30 cm (12 in) tall. Distinctly yellowish (sometimes mottled) plants are scattered around fields (see Fig. 5). The disease is most prevalent in older stands because it builds up gradually. The pathogen does not survive in the soil and is not carried by seed so most new stands are disease-free. The disease is spread from infected plants by certain beetles but more commonly by harvesting equipment. The disease is less common on pastures than mechanically-harvested fields.

Plants infected with CMV lose vigour and eventually die. Because infected plants diminish and die, it is rare to see more than 10% infected plants in a field. CMV is very likely a major cause of stand decline and weed encroachment in orchardgrass in our region. There is no information on whether CMV reduces forage quality.

To reduce spread of the disease, farmers should plant resistant varieties (consult extension agent). Cleaning harvesting equipment, especially after harvesting older infected fields will slow spread of the disease. Harvesting clean fields before infected ones should also help to slow the spread of CMV.

Insects — Leatherjackets

Leatherjackets are serious pests of forage crops and lawns in many parts of coastal BC and the Pacific Northwest. The first North American report of leatherjackets came from Cape Breton Island, Nova Scotia, in 1955 and the first BC sighting was in lawns in Vancouver in 1965.

Leatherjackets are the larvae of the European marsh crane fly, which resembles a giant mosquito with a body length of 2.5 cm (1 in — Fig. 6). The crane fly has one generation per year. Adults emerge from the soil in August and September and mate immediately. Each female lays about 280 shiny black eggs in the grass within 24 hours of emerging.

Adult crane flies live only one week.

The eggs hatch within two weeks into grey, legless 3-mm (1/8-in) long larvae with a tough leather-like skin, giving its name. The larvae (leatherjackets) feed on the crowns and tops of grasses in the fall and over-winter in the larval stage. The larvae can withstand both cold weather and flooding. The leatherjackets resume feeding in spring as the soil warms, causing most damage in March and April. They do little feeding after they reach full size in May. Heavily infested grass stands produce little growth before mid-May. Leatherjackets pupate in July and August and the mature pupae work their way to the surface to protrude about 1 cm (1/2 in) when the adults emerge.

Leatherjackets are too small to be easily detected in the fall. The best time to test for leatherjackets is after they begin to actively feed in early March. At least ten different locations in a field should be tested, including high and low areas. The simplest method is to force the leatherjackets to the surface by applying gasoline at a rate of 250 ml (one cup) per 30x30 cm (1 sq. ft.) of area. A more accurate method is to dig up 15 x 15 cm (6 x 6 in) pieces of sod about 5 cm (2 in) deep and submerge in a pail containing a saturated salt solution (saturated salt solutions will float a potato). Wait for 5 minutes and the leatherjackets will float to the surface where they can be counted.

Typically, control is warranted when more than 20 leatherjackets are seen per 30 x 30 cm (1 sq. ft.) area. Consult local pesticide recommendations for the latest approved control method.

Mammals — Moles

Moles are small greyish-black tunnelling mammals that have tiny or no eyes. Moles feed mainly on earthworms and both harmful and beneficial soil insects and their larvae. The grass growing above tunnels is usually stunted or killed but the effect on entire fields is usually small. The greatest problem for farmers are the mounds of soil that dull cutting blades and contaminate feeds.

There are no registered methods for baiting or chemically controlling moles in BC. The only available method of control is trapping, typically with English scissor-type traps. Trapping is most effective in November to March. Test for current runways by stamping existing mounds.

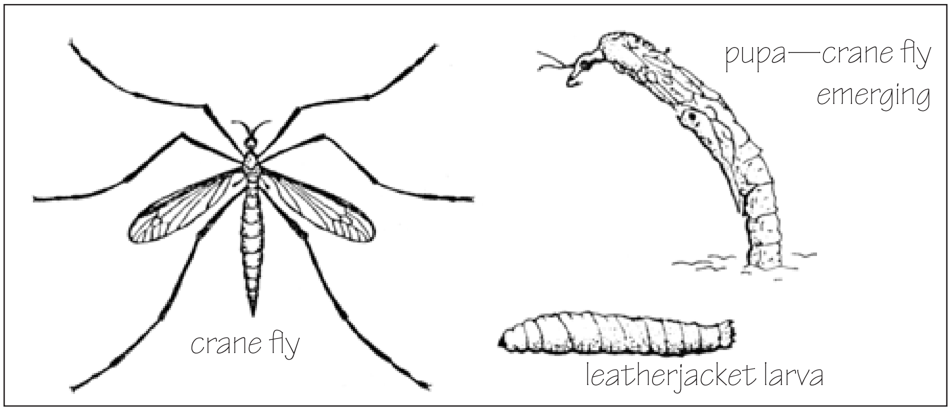


Figure 6. Adult crane fly and destructive leatherjacket larva. (Drawings from BCMAF Publication.)