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The Botany, Ecology, Agronomy and Control of *Poa trivialis* L. - Rough-stalked Meadow-grass.

by

G.P. Allen

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Summary

Much of the available literature on *Poa trivialis* L. is reviewed and the agronomic importance of the species is discussed from the viewpoint of its botany and ecology. Herbicidal and non-herbicidal control measures are described.

List of Contents

POA TRIVIALIS L.

Common name:- Rough-stalked meadow-grass, rough meadow grass, G.B.
Rough Blue-grass N. America.
(Poa - ancient Greek for grass or fodder)

The genus Poa, which consists of about 250 species, is placed in the tribe Festuceae of the Gramineae.

Poa trivialis is a loosely tufted perennial 20-100 cm high, with creeping leafy stolons according to Hubbard (1954) but with stem shortly creeping, not stoloniferous according to Clapham, Tutin and Warburg (1962), who also classify this species as a semi-rosette hemicryptophyte or a herbaceous chamaephyte. Culms erect or rather weak and usually spreading from a decumbent base, slender to somewhat stout, 3-5 noded, smooth. Leaves folded in shoot, yellow-green to purplish, hairless, sheaths entire, usually rough, rarely smooth, keeled; uppermost sheath longer than its leaf. Ligule of uppermost leaves 4-10 mm long, glossy and acute, but of lower leaves often short. Blades tapering gradually, abruptly and sharply pointed to a boat-shaped tip 3-20 cm long, folded at first, afterwards flat, 1.5-6 mm wide, flaccid to firm, minutely rough or nearly smooth, glossy with rounded centre ridge or keel below; upper surface dull, ribless. Motor cells well developed on either side of central bundle and appearing as parallel 'tram' lines.

Panicles broadly ovate to oblong erect or nodding, lax or contracted and rather dense, 3-20 cm long up to 15 cm wide, purplish, reddish and green; branches scabrid, mostly in clusters of 3-7 spreading, bare and undivided to the lower part; pedicels 0.3-2 mm long.

Spikelets ovate to elliptic or oblong, compressed, mostly 3-4 mm long, 2-4-flowered, breaking up at maturity beneath each lemma. Glumes persistent, finely pointed with distinctly toothed keels, lower lanceolat 2-3 mm long, 1-nerved, upper ovate, 2.5-3.5 mm long, 3-nerved. Lemmas overlapping at first, later with incurved margins, lanceolate and pointed in side view 2.5-3.5 mm long, keeled, with short hairs on the keel up to midway and a mass of cottony, crinkled hairs at the base, the rest hairless, distinctly 5-nerved, with membranous tips and margins. Paleas nearly as long as the lemmas, with two minutely scabrid keels. Anthers 1.5-2 mm long.
Seed: 1.8-2.5 mm long and narrower than those of P. pratensis, the grain tightly enclosed by the hardened lemma and palea. The outer palea is acute at the apex and 5-nerved; only the dorsal and marginal nerves are prominent, giving a sharply triangular cross section to the 'seed'. Hairs may be present on the lower half of the dorsal nerve (keel), but none are present on the remaining nerves. The 'web' at the base of the palea is less copious than that of P. pratensis.

Commercially cleaned 'seeds' are usually quite free from hairs except for a trace of the 'web'.

Armstrong (1937) provides a key for the differention of the seed of 6 Poa spp. The key is based on the nature of teeth on the upper part of the dorsal nerve of the outer pale as seen on cleaned seed at a magnification of x40.

Origin and distribution

Poa trivialis is of West European origin. It has been recorded in every vice county in Great Britain, Ireland and the Channel Islands. The distribution of P. trivialis in the British Isles is mapped in the Atlas of the British Flora (Perring and Walters 1962). P. trivialis is very common in meadows and pastures of the lowlands, especially on rich, moist, heavy soils. It is also frequent on waste and cultivated land, on pond and stream margins and sometimes under partial shade. P. trivialis thrives at elevations up to about 500 ft in Britain. Also recorded throughout Europe, temporate Asia, North Africa and introduced to North and South America and Australia, etc.
Baker (1962) discussed the place of Poa trivialis in a survey of English grassland. He noted that P. trivialis occurred in varying amounts in almost all sward types and, with the Agrostis species, was often a major contaminant of leys after two or three years.

Economic value

The nutritive value and palatability of P. trivialis is high. It is sometimes sown in seed mixtures for long leys on rich, moist, heavy soils to act as a bottom grass. Its low, vigorous growth, which remains green in winter, helps in maintaining a close sward. It is sown in second quality lawns and recreation grounds but should not be sown alone Greenfield(1962). Of recent years the use of this grass has declined.

The species is now regarded as an undesirable grass in some situations and where it is desired to keep sown swards pure. P. trivialis can produce fast and freely enough in arable crops to the extent of being a weed.

Flowering period

June, July and August.

Mode of reproduction

Mainly outcrossing. Effective reproduction is by seed and stolons.

Chromosome number

2n = 14 (polyploid numbers 14, 28; aneuploid 27)

Germination

Fast - 60-70% in 7 days (experimentally)
85-90% in 21 days.

The Copenhagen Tank system is the best for testing small-seeded grasses like the Poa and Agrostis species and fine-leaved fescues. Armstrong (1937) states that temperatures ranging between 15° and 25°C are suitable for ryegrasses, oatgrasses, fescues and timothy, but Poa and Agrostis species, cocksfoot, dogstail and others germinate better where the temperature range is wider e.g. 15° - 30°C. Germination of the Poa species is frequently stimulated by sharply alternating temperatures, e.g. 18 hours at 18° - 20°C followed by 6 hours at 30°C daily. Bright light also accelerates their germination.

Chippindale (1949) found that the germination of Festuca elatior, F. pratensis, Phleum pratense and Poa trivialis was very much depressed by constant temperatures of 5 - 10°C, while that of Alopecurus pratensis, Arrhenatherum elatius, Cynosurus cristatus and Lolium perenne was comparatively unaffected. Harrington (1923) states that Poa species germinate better at alternating temperatures, as do Agrostis alba, and Dactylis glomerata. After-ripening dormancy of many Poa species is removed by chilling at 5 - 10°C.

Poa trivialis averages 2,300,000 seeds per pound (5,066 seeds/gm) compared with 237,000/lb (522/gm) for ryegrass.
Sonneveld (1958) provides tables showing numbers of seed per kg. of Lolium perenne, Festuca pratensis, Phleum pratense, Dactylis glomerata, Poa pratense, P. trivialis, Lolium multiflorum, Trifolium pratense and T. repens.

A SPECIES COMPARISON OF THE QUANTITIES OF
SEED RECOMMENDED TO SOW ONE STATUTE ACRE

	Millions of germinating seed	Weight of germinating seed (lb)	Weight of seed average real value (lb)
Poa trivialis	23	10	12
Lolium perenne	7	30	34
Phleum pratense	15	14	15
Festuca pratensis	8	30	35

	Millions of germinating seed	Weight of germinating seed (lb)	Weight of seed average real value (lb)
F. rubra	12	24	30
Agrostis alba	30	6	8
Dactylis glomerata	9	20	24

Commercial seed of Poa trivialis consists of the single grain plus rachilla. The main commercial source of Poa trivialis seed is Denmark Greenfield (1962).
Koning (1957) reporting on seed crops of P. trivialis in the Netherlands, stated that these occupied 1 ha in 1949 but had risen to 500 ha in 1956. Of this area 60% was located in N.E. Polder where the absence of P. annua was an advantage. Seed yields of approximately 940 kg per ha were obtained. Armstrong (1950) states that well cleaned seed should not contain more than 5-7% chaff, or 1% of foreign seeds. Among weed seeds Alopecurus geniculatus is an almost invariable impurity and Holcus lanatus and Cerastium vulgatum are also frequently present. Purity of Poa trivialis should reach 90%.

Depth of sowing. Sonneveld (1948) described experimental sowings of Lolium perenne, Phleum pratense, Poa pratense, P. trivialis, Trifolium pratense and T. repens in a sandy soil at depths ranging from 0 - 5 cm and with different seedbed treatments (rolling or no rolling). He claimed that even when a drill is used, grass and clover seed should not be sown deeper than 2 cm (0.75 in.) and the soil must not be loose. Sonneveld (1958) provided tables showing the percentage germination of seeds of the above species together with Festuca pratensis, Dactylis glomerata and Lolium multiflorum, at depths ranging from 0-5 cm. Optimum germination of Dactylis glomerata occurred at 2 cm depth but the other species germinated best at 1.5 cm; smaller seeds were unable to emerge from depths greater that 2 cm. For all these species he stated that spring sowings should be completed by mid-April and late sowings by 1st September.

Buried seed

Viable buried seed is widely held to be one of the most important sources of invasion by undesirable grasses of sown leys, reseeded pastures and meadows Evans (1963).

Boeker (1959) at Rengen, Eifel, studied the rejuvenation of pastures by seed dissemination. Samples of manure from cattle stalls and of soil from cattle resting places, tracks and drinking places were removed to glasshouses for observations on plant emergence during a period of two years. Seedlings emerging from samples of manure 2-3 years old (taken from a depth of 45 cm) were mainly Trifolium repens but samples of the top layers of manure 6-8 months old, yielded a variety of clovers and grasses, the most numerous grasses being Poa trivialis and P. pratensis. Fairly numerous were Dactylis glomerata, Holcus lanatus and Lolium perenne. The most numerous species in the various soil samples were Juncus bufonius, Poa trivialis, P. annua, P. pratensis, Plantago major, Agrostis tenuis and Sagina procumbens.

Salzmann (1939) took samples of fresh manure over 9 consecutive months. Seed was separated from the manure and sown and one year's counts showed 4 kg of fresh manure to contain an average of over 800 viable seeds. Fourteen grasses were listed. Poa trivialis constituted 83% of all the viable grass seed present.
Milton (1934) investigated the buried viable seed of enclosed and unenclosed hill land in Wales, with the following results:

1. In fields up to 5 years old, the maximum quantities of buried viable seed to a depth of 7 in. in the soil were:-

Lolium perenne	0.20 million/ac
Festuca rubra	1.53 "
Poa trivialis	8.47 "
Holcus lanatus	8.76 "
Agrostis spp.	11.20 "

2. In fields with swards over 5 years old:-

Lolium perenne	$<$ 0.20 million/ac
Festuca rubra	1.52 "
Poa trivialis	1.73 "
Holcus lanatus	12.20 "
Agrostis spp.	9.28 "

Seed numbers of Agrostis spp. on dry slopes may reach 56.5 million/ac. Sijbring (1963) notes that Poa trivialis at 10.2% moisture content survived for 16 months at 48% relative humidity in airtight containers without loss of viability.

Soils and climate

Poa trivialis grows most luxuriantly where the climate and soils are decidedly moist, e.g. in the west of Britain or on rich, moist clays, fen soils etc. It grows well in partial shade. Stassen (1953) states that shade from fruit trees reduces the amount of Trifolium repens while encouraging a stronger growth of P. trivialis, Agrostis alba and Dactylis glomerata. Irrigation (with either fresh or sewage water) encourages the growth of P. trivialis. The thin creeping stolons or stems are very shallow rooted and the plant is dependent upon the surface moisture.

In dry situations or seasons, the plants become much dwarfed and the foliage turns red, but as soon as rain falls it is capable of rapid recovery from the effects of drought. One of the reasons why this grass is not generally recommended for sowing is its relatively low productivity under dry conditions.

Vries (1938) recorded the recovery of grassland from drought in 1935. The proportion of Poa trivialis on clay soil had been greatly reduced, while that of white clover had increased, as also had that of Agropyron repens and other weeds. The ensuing wet year, 1936, resulted in a complete restoration of botanical balance and the proportion of P. trivialis rose from 6.5 to 19.5%. The proportion of Trifolium repens, though lower than in 1935 (17.5%), was still 10.5% and the proportion of Agropyron repens fell from 5 to 1%.

Carroll (1943) studied the effects of drought, temperature and nitrogen on turf grasses. Poa trivialis was among the species most injured by soil drought. Low soil temperatures were more injurious than low air temperatures and high soil more than high air temperatures. Lethal soil temperatures were between -10 and -15°C and between 50 and 60°C. Plants from high nitrogen section were less able to withstand soil drought, cold or heat than were the same species when grown under conditions of lower nitrogen supply.

In mild winters Poa trivialis gives an appreciable amount of herbage and makes early spring growth. Its maximum production is reached by May or June, after which production usually falls off considerably for the rest of the season. In wet seasons and especially if nitrogen is available, it continues to give rapid and large responses whenever the temperature is favourable to growth. Its response to nitrogen and its yield and seasonal productivity are in fact largely dependent upon the moisture supply. In moist districts its tiller production and yields are maintained at a high and fairly consistent level from early spring until autumn.

Poa trivialis is fairly resistant to frost and can invade a sward where Lolium perenne has been reduced by frost.

Vries and Hart (1941) studied the effects of severe cold on turf in the Netherlands. A sudden severe frost without snow cover was recorded in December 1938 after a mild autumn. The frost changed the botanical composition of grassland in the south of Holland. The percentage of grass fell from 96 to 82 in pasture land and from 94 to 84 in haylands. Broad-leaved weeds increased from 3 to 11 and from 5 to 16%, respectively.

Lolium perenne and Holcus lanatus were to an important degree replaced by Phleum pratense and Poa trivialis. Further severe cold was recorded in the winter of 1939-40. Taking the two years together, the effects seem to have been worst where previous heavy rains had left waterlogged conditions.

Lolium multiflorum, Anthoxanthum odoratum, Cynosurus cristatus, Holcus lanatus and Lolium perenne were very susceptible to frost. However, great varietal differences were noted in the last named species, old indigenous strains proving by far the most winter-hardy. Great hardiness was exhibited by Phleum pratense, Agropyron repens, Poa pratensis, Festuca rubra, Agrostis species, Alopecurus pratensis and A. geniculatus. An intermediate position was taken by Trifolium repens, Arrhenatherum elatius, Bromus mollis, Poa annua, P. trivialis, Festuca pratensis, Dactylis glomerata, Hordeum secalinum and Trisetum flavescens. Good tillering capacity enabled English wild white clover to recover quickly. Work by Caputa (1956) in French Switzerland substantiates the findings of de Vries and Hart.

Growth form - vegetative growth and root growth

Poa trivialis is extravaginal in habit. Whilst young it forms tufts and remains tufted if grown under dry conditions. Later, and especially in the presence of moisture, it covers large patches of ground by forming secondary roots and tufts of foliage at the nodes of its numerous thin stolons. Hubbard (1954) states that P. trivialis is a loosely tufted perennial with creeping leafy stolons. Clapham, Tutin and Warburg (1957) describe this species as having stems shortly creeping, not stoloniferous. Thomas and Davies (1938) regard the tufts as loosely spreading and describe the root system as fibrous, with small tufts at nodes of rhizomes. Vries (1940) notes that although Poa trivialis makes dense sods, its roots do not penetrate into hard dry soils. However, the habit of growth aids the conservation of surface moisture and to a large extent prevents the establishment of other competing species. Being a bottom grass the species withstands close grazing and mowing better than most grasses and makes good recovery. It combats soil erosion by nature of its growth form.

It is resistant to flooding by fresh water and does very well in water meadows. Reyntens (1949) studied the resistance to flooding of different grass and clover species in the Dender, Scheldt and Durme valleys of Belgium. The species were sown is special cement boxes which could be submerged as under the natural conditions of the periodically flooded river valleys. Three groups of species were distinguished -

1) Destroyed by flooding: Lolium perenne, L. multiflorum Festuca pratensis.

2) Generally destroyed by flooding: Trifolium hybridum, T. pratense and T. repens.

3) Resistent to flooding: Alopecurus pratensis, Poa pratense, P. trivialis, Agrostis species.

Stoffers and Knapp (1962) also refer to flooding of Poa trivialis. Poa trivialis does not tolerate saltwater.

Close defoliation favours Poa trivialis and this likewise favours the growth of clovers and the species is capable of blending well with wild white clover. However, under conditions of high nitrogen P. trivialis will tend to oust clovers. P. trivialis tends increasingly to oust low fertility species the better the manurial treatment.

Milton (1940) noted that on hill pastures in Great Britain, Nardus stricta and Agrostis species were replaced by the more nutritious species, such as ryegrass, Poa trivialis and P. pratensis when lime and phosphate were applied. Swards treated in this way had higher feeding values than the originals.

Rhode Island State College (1941) studied the root development of pasture grasses and distinguished between species according to whether their roots were regenerated annually or persisted for more than one year, although not necessarily for the life of the plant. Species with annual roots are Phleum pratense, Festuca pratensis, Poa trivialis, Lolium perenne, Agrostis alba and Agrostis tenuis. Species with perennial roots are Poa pratensis, P. compressa, Dactylis glomerata, Agropyron cristatum, Phalaris arundinacea. Generally, new annual roots developed more or less simultaneously and could number 20-30 per plant. Maximum production of new roots occurred during the last week of March and maximum growth during the first two weeks in April. Very few new roots developed after the flower primordia were initiated. In Poa trivialis, roots regenerated every year, active new growth of roots beginning in autumn. The old roots disintegrated soon after the new had become established. The greatest increase in root weight took place between March and July (Netherlands). Mowing and grazing have little effect on root weight. Poa trivialis and Phleum pratense have a high percentage of root weight in the top 0-5 cm soil layer. Festuca pratensis and Trifolium repens however, have a lower percentage in this layer and Poa pratensis still less.

Flower induction

Cooper and Calder (1964) showed that most temperate perennial grasses posessed a definite inductive requirement. Poa trivialis, P. pratensis, Cynosurus cristatus, Dactylis glomerata, Festuca pratensis and F. rubra did not respond to seedling induction and possibly go through a juvenile stage before becoming able to respond to inductive conditions. However, the young seedlings of a few species, e.g. Lolium perenne, responded to both cold and short day-lengths. Others, such as Phleum nodosum, Agrostis alba, A. canina, A. stolonifera and A. tenuis, responded to short-day induction but not to cold.

Productivity

Milton (1934) investigated the relative palatibility of seed mixtures on natural hill pastures and gave data for the relative amount offered and relative amount eaten of various grass and clover species under light and heavy grazing. Under both intensities of grazing, Dactylis glomerata produced the largest amount of herbage, while production of Lolium perenne was almost as high. Phleum pratense occupied an intermediate position between these species and Poa trivialis, the latter with Trifolium pratense and T. repens, offering the least herbage.

Digestibility and yield of digestible dry matter

Limited work on the digestibility of Poa trivialis has been carried out by the Grassland Research Institute at Hurley (1964). In experiment no. H318, irrigated, pure swards, cut frequently and receiving 500 lb nitrogen per ac per yr gave the following yields in the second and third harvest years (1963 and 1964, respectively):

	Yield of dry matter '00 lb per acre
Cocksfoot S.37	84
Perennial ryegrass S.24	88
Poa trivialis (volunteer)	62

In Experiment no H.373, pure swards in their first harvest year (1964) were treated as in H.318 and gave the following yields:

	Yield of dry matter '00 lb per acre.	Mean % digestibility of dry matter in May and June.
Cocksfoot, S.37	82	72.6
Perennial ryegrass, S.24	74	76.5
Poa trivialis (danish)	58	76.5
Poa pratensis, S.63	68	73.4

These results and others from a further experiment (HE 45/62) suggest that while the digestibility of P. trivialis dry matter can be higher than 70%, the yield of dry matter at this level of digestibility generally falls well below that for ryegrass and cocksfoot. The gap is certainly wider than suggested by the results reported here because these trials were carried out under conditions of high fertility and irrigation known to favour P. trivialis. In addition, production from P. trivialis is often low in dry years.

Grazing management

Blackman (1933) carried out investigations during 1928 to 1932 on nine intensively managed pastures in six localities differing both in soil and climatic conditions. Periodic determinations of the botanical composition showed that under a system of rotational grazing and nitrogenous manuring there were no common trends in changes in the botanical composition of swards. Comparison of data for manuring and grazing with the botanical fluctuations indicated that differences in time and severity of grazing from year to year influenced the botanical composition more than did differences in manuring. The conclusions reached were that:

i) Hard grazing in the spring and autumn leads to a suppression of Lolium perenne; conversely, light grazing at these times increases this species.

ii) Hard grazing during May and early June is unfavourable to the development of Poa trivialis. On the other hand, light grazing does not necessarily increase P. trivialis, since this species may be suppressed by competition from Lolium perenne, which is also favoured by these conditions. The intensity of this competition is influenced by the severity of the grazing either earlier in the spring or in the previous autumn.

iii) Undergrazing during mid-summer results in an increase in Agrostis species and hard grazing in a decrease. Undergrazing at this period may result in a relatively greater increase in Agrostis species than the increase of Lolium perenne brought about by light grazing in spring. It was considered that this difference is due to the inferior palatability of the Agrostis species. When stock are turned onto the pasture in mid-season, much of the Agrostis is trodden underfoot and not eaten; in the spring L. perenne is grazed, but not trodden down in the same way.

iv) Hard grazing during mid-season brings about an increase in Trifolium repens and undergrazing or the taking of a late hay crop a decrease. Undergrazing in May or the taking of an early hay crop does not reduce the content of T. repens.

The mechanism by which grazing can bring about these changes in the sward would appear to be related to differences in the seasonal productivity of the dominant species. These differences lead to differences in the intensity of defoliation, according to which species is in flush at the time of grazing. On such a hypothesis nitrogenous fertiliser per se can have little effect on the composition of the sward, except that such manuring increases the slope of seasonal productivity curves, thus increasing the effect of differences in time and severity of grazing.

It is suggested that from a knowledge of the seasonal productivity curves of the dominant species in any sward, it is possible to foretell to some extent the botanical changes likely to be produced by variations in stocking.

Jones (1933) investigated the factors influencing the growth of pasture plants and stated that for Poa trivialis, as for ryegrass, the longer period of winter and spring rest (November to April) as compared with the shorter rest (February to April) benefitted the Poa when sown alone and in fact the amount doubled. Yet when sown in mixture, the meadow grass fared relatively worse (reduced by half) with the longer winter rest. This was no doubt due to the greater competition from the ryegrass, which was favoured by the winter rest even more than the Poa.

The reaction of Poa trivialis and perennial ryegrass to rest in May brought into prominence the fact that grazing in the early spring (previous to May) weakened the grasses which produced the most growth during that period (i.e. ryegrass) much more than those which were relatively non-productive at this time, (i.e. Poa) the sequel being that during the period of rest in May the latter was able to profit relatively more. In the pure seeding plot P. trivialis increased with rest in May from 25.4 to 29.7 whilst pure ryegrass decreased from 15.3 to 3.6%. Similarly in the mixed plot the rest in May caused an increase in the Poa from 2.9 to 7.2 whilst the ryegrass showed a decrease from 40 to 32.2%. Light grazing in spring and summer and none in winter resulted in swards consisting mainly of Lolium perenne, Poa trivialis and Agrostis stolonifera.

In favourable situations, Poa trivialis produces a considerable bulk of 'top grass' which makes hay of the finest quality. The production of aftermath is not usually large but may be quite good in districts of high rainfall.

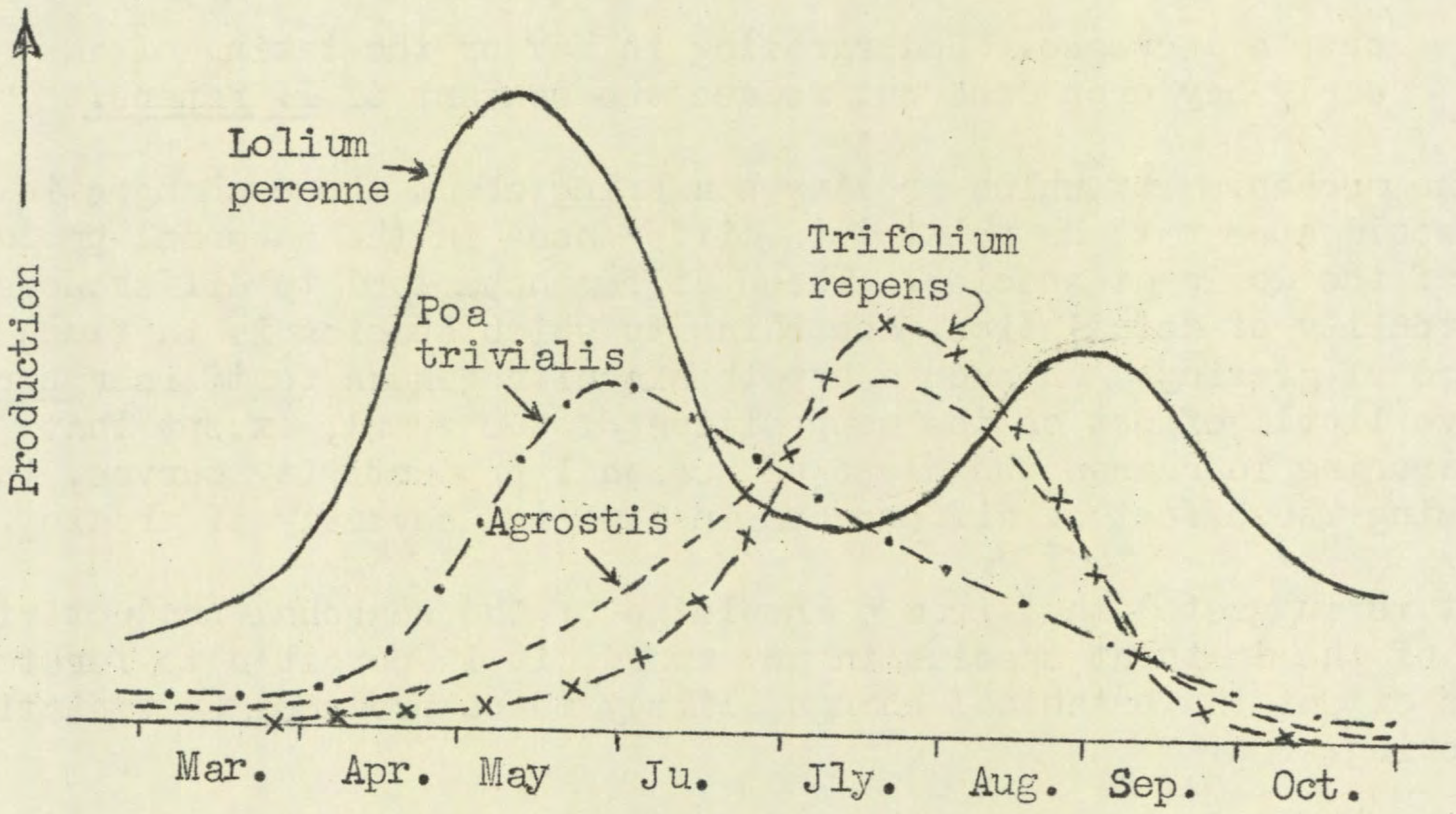

Fig I. Seasonal Productivity Curves for Dominant Species in Agrostis/Lolium Pasture.

Fertiliser treatments and pasture growth

Blackman and Lewis (1935) observed the growth of pasture in the spring and its relationship to available nitrogen supply and temperature at Jeallotts Hill (Berks). One pasture type studied contained Poa trivialis and Cynosurus cristatus as dominants. Nitrogenous manures were applied in late February or early March. In some experiments plots were first harvested at the beginning of May, in others sub-plots were cut at short intervals from late March until mid-May. Data were obtained on:

i) the increase in yields due to nitrogenous manuring when the grass was cut at the time cattle would normally be turned out,

ii) the degree of earliness, produced by nitrogenous manuring.

In early May $(NH_4)_2SO_4$ at 1 cwt/acre gave yields 41%, 20%, 74%, 87%, 21% greater than control in 1930-34 respectively. An application of 3 cwt/ac increased yields 105%, 129%, 121%, 300% and 79%. Ammonium compounds gave bigger yields than Urea, $Na(NO_3)_2$ or $Ca(NO_3)_2$.

Pasture treated with nitrogen reached grazing stage earlier than untreated controls. Below a soil temperature of 40°F (5°C) at a depth of 4 in. little if any pasture growth took place. Temperatures below 40°F (5°C) did not inhibit uptake of added nitrogen nor its translocation to the shoot. At a temperature of 41-43°F (5-6°C) growth commenced but until a temperature of 48-50°F (9-10°C) was reached, herbage treated with nitrogen grew more quickly than the control. It was therefore concluded that between the range of 42°F (5.5°C) and 49°F (9.5°C) growth of untreated pasture was limited by lack of available nitrogen. When the temperature of 50°F (10°C) was reached there was a more rapid release of available nitrogen due to (micro-organisms). This release resulted in a spring flush of grass. It was concluded that the degree of earliness produced by nitrogenous manuring may be dependent on the length of the period for which the soil temperature remains between 42 and 49°F (5.5 - 9.5°C). These findings applied to swards dominated by the following also,

i) Lolium perenne
ii) Agrostis species
iii) Festuca ovina

Wind and Vries (1954) noted that in permanent grassland, Lolium perenne and Trifolium repens increased where organic, especially liquid manure was used but Holcus lanatus and Poa trivialis responded better to inorganic manures. These results were marked on grassland used for hay and hay/grazing but differences were less marked on grazed pastures.

Seasonal production under irrigation and high fertility

Green et al (1964) investigated the seasonal production of various grass species grown under irrigation and given 2 lb N/ac/day between 23rd April and 27th September and 1 lb/day at other times, plus adequate PK. Active growth began in early April and a maximum of 70-80 lb dry matter ac/day was produced in early May. Growth fell during July to about 50 lb in ryegrasses and cocksfoot and to 40 lb DM/ac/day in tall fescue. S.48 and S.51 timothy produced 30-40 lb DM/ac/day in early July and 50 lb in late July. Deceleration of growth began in cocksfoot and timothy after early August and in ryegrass after mid-August. Poa trivialis began active growth in mid-April, reached a maximum of 60 lb in late May and produced 30 lb DM/ac/day in July and August. A mixture of perennial ryegrass and white clover without applied nitrogen began active growth in mid-April, produced 50 lb in mid-May and 45-50 lb DM/ac/day thereafter until late July.

Invasion of Poa trivialis in grassland

Poa trivialis normally invades swards on land of inherently high fertility, particularly where the application of bag nitrogen is high. Laity (1956) suggests that Poa trivialis is likely to invade new pastures particularly under the influence of phosphate. Poa trivialis has been known to arise from various sources, e.g. buried viable seed, impurity in the sown seed (very small amounts), vegetative carry over from previous crop, dung or hay dropped on the field. It has a widespread tendency to be associated with overgrazing, high stocking and winter and wet weather poaching on slow draining soils. P. trivialis germinates rapidly and fills up the bare gaps in swards which are open for various reasons. It is thus prevelant in poorly established swards or swards of 'top grass' species such as timothy/meadow fescue, cocksfoot leys, rather than in leys of aggressive species such as perennial ryegrass. It is a quick coloniser of poached ground round gates and cattle troughs and in ruts etc.

Edmond (1964) in New Zealand observed some effects of sheep treading on the growth of 10 pasture species (including Poa trivialis) grown on a silt loam of moderate structure and fertility, kept at field capacity. Mown plots of 8 grasses and 2 clovers were trodden by the sheep at stocking rates from 4-32 animals/ac throughout the year. All species decreased with treading although Poa trivialis actually invaded. The treading effect was greatest in autumn and least in summer. White clover and Agrostis tenuis were relatively more tolerant in summer, short rotation ryegrass in winter. The number of tillers rather than tiller vigour was reduced by treading. At 32 animals/ac species could be ranked, placing the least affected first.

Perennial ryegrass *
Poa pratensis
P. trivialis
Short rotation ryegrass *
Agrostis tenuis
Trifolium repens *
Timothy *
Cocksfoot
Trifolium pratense
Holcus lanatus

* heavier stocking tended to favour these species as 3-5 sheep ac/yr is the normal rate.

Mechanical control measures

Reyntens (1952) (Belgium) gives results of trials with a pasture renovator consisting of vertical knife-edged tines, mounted on a tractor tool bar and designed to tear out rhizomatous grass weeds and aerate consolidated pasture soils. This treatment was combined with resowing of desirable grasses. The trials were carried out in orchards and on old established pasture and meadow. The results showed that inferior grasses, e.g. Agrostis species, Bromus mollis, Dactylis glomerata, Poa trivialis and Trifolium hybridum were very sensitive to mechanical treatment. Among the less susceptible species were Festuca rubra, Trifolium repens, Phleum pratense, Agrostis stolonifera and Agropyron repens. Among the resistant species were Lolium perenne, F. pratensis and Poa pratensis. Within the year, the treatment caused marked reduction of Agrostis species, Poa trivialis and Holcus lanatus in hay meadows and a marked increase in the proportion of Lolium perenne and L. multiflorum in the sward. The species sown at the time of treatment was L. multiflorum.

Parasites, etc. on Poa trivialis

Volk (1937) investigating Typhula graminum found Poa trivialis, P. annua and Hordeum murinum highly susceptible. Agrostis alba, Holcus mollis, Lolium perenne, Phleum pratense, were slightly susceptible. Alopecurus pratensis and Festuca pratensis were uninfected.

Poa trivialis is prone to attack from Fusarium nivale on upland pastures in N. Scotland, particularly pastures receiving no fertiliser dressings (N.S.C.A. Aberdeen 1958).

Some observations of the parasites on Poa trivialis were noted by the Welsh Plant Breeding Station in 1919-1921. Septoria culmifida Korst. could produce abundant pycnidia on the sheaths and laminae particularly from April to June. This species accounted for the brown appearance of Poa trivialis during these months. The fungus was also common on the aftermath in October and present to a lesser extent in the winter months.

Uromyces Poae. Raben was recorded in December and June but was never abundant. Traces only of Scolecotrichum graminis Fel. were recorded on this host.

Epichloe typhina. Tul. was observed on P. trivialis and flowering tillers attacked by the fungus did not produce panicles.

Goodey (1941) observed Anguillulina depsaci from 'tulip root' of oats injuring seedlings of a grass seeds mixture and found Poa trivialis to be infected to a greater or less degree.

Poa trivialis is also very susceptible to Oat Eelworm-Heterodera major. However, this does not seriously affect growth.

Thomas (1938) working on the bionomics and structure of some Dipterous larvae infesting cereals and grasses, studied Geomyza (Balioptera) puntata fall. The chief hosts of this insect in the field were Lolium perenne or L. italicum. In laboratory experiments the following hosts, in addition to the above, were preferred in the order given: wheat, barley, Poa trivialis, Dactylis glomerata, Cynosurus cristatus, oats and Festuca rubra. Damage is similar to that caused by Oscinella frit: the larvae feed inside the grasses and kill the central shoot.

Miscellaneous

Carroll and Welton investigated the daily periodicity of the stomata of Poa pratensis, Poa trivialis, Agrostis alba, A. tenuis and Festuca rubra var. fallax. Stomata of all the species showed a definite periodicity but there were differences between the species and the percentage of stomata open at the same time. The fescue had fewer stomata per unit area than the other species.

The chemical control of Poa trivialis

a) In crops of dicotyledonous species

Both paraquat and dalapon can be used for the selective control of P. trivialis in lucerne. Jones (1962) investigated and compared the value of paraquat and dalapon sprayed in March 1961, in controlling P. trivialis in established du Puits lucerne and the subsequent effect in productivity. Paraquat at 0.25 lb/ac was effective in eliminating P. trivialis and gave superior control to 4 lb/ac dalapon. He noted that damage to lucerne was avoided by applications made while lucerne was winter dormant. The control of Poa in the early part of the season particularly, resulted in a significant increase of lucerne yield but not of total yield which was similar in control and treated plots. Work done by the Weed Research Organisation in experiment no. AG.9.62 Allen (1963), agrees largely with the findings of Jones (1962). Information was obtained on the control of Poa following applications in mid-April, early August, mid-October and mid-March.

Paraquat and dalapon have also been applied over a wide range of dates at sward destruction and lower rates to a variety of swards containing white clover - Trifolium repens and Poa trivialis; see experiments no. AG. 1,3,4,5 and 13.62 (Allen, 1963) and trials discussed under (b) below. Bearing in mind that a number of other grasses, and dicotyledonous species were usually present it can be said that these chemicals selectively control Poa trivialis growing with white clover at all times of the year. The results suggested that the rates of paraquat from 2-3 oz/ac and dalapon at 1.5-3 lb/ac would give useful control of P. trivialis in established clover sown pure for seed, hay or silage, and that these treatments would be best applied when clover was in a dormant state, and when Poa was most susceptible to spraying, i.e. late autumn (November).

b) In Grassland

The chemical control of grasses (including Poa trivialis) in permanent pasture has been reviewed by Elliott and Allen (1964). Although the selective control of grasses is still very much in the experimental stage the following work on swards containing Poa trivialis is worth noting.

i) Work by A.R.C. Weed Research Organisation

Numerous chemicals have been screened on pure stands and simple mixtures of grasses at W.R.O. and the results of these trials are documented in the form of written up experiments carried out by the Evaluation Section of the Department of Weed Science.

	E.28.62 (1), (2) & (3)
Experiments no.	E.1.63, E.1 A.63. include work on chemicals applied
	E.1, 18 & 19.65. to Poa trivialis.

Work on managed, lowland grassland containing P. trivialis has been carried out by the Grassland section of the Agronomy section of the Department of Weed Control at W.R.O. The following experiments contain useful information on the response of P. trivialis to dalapon and paraquat (and in the case of AG.13.62. to amitrole-T) at various times of the year.

AG. 1. 62.	AG. 3. 64.	AG. 7. 65.
AG. 3. 62.	AG. 4. 64.	AG. 8. 65.
AG. 4. 62.		AG. 9. 65.
AG. 5. 62.		AG. 10. 65.
AG. 9. 62.		AG. 11. 65.
AG. 13. 62. (Allen 1965)		AG. 12. 65.

ii) Work by other persons

Jones (1962) applied dalapon at 10 lb/ac to a mixed lowland sward in April 1960. Assessment by yield on 7th October 1960 showed ryegrass, cocksfoot, Agrostis stolonifera and Poa trivialis to have been reduced by the chemical. Ryegrass was reduced by 25%, cocksfoot and P. trivialis each about a third and Agrostis stolonifera by 75%. White clover and other dicots increased markedly.

Bramley (1961) working in New Zealand reported the application of dalapon at 3.7 and 7.4 lb/ac in December and March to separate blocks of Lolium perenne, Dactylis glomerata, Agrostis tenuis, Festuca rubra var. fallax, Holcus lanatus and incidentally P. trivialis which was a volunteer on the blocks. All the species had been established 3 yr at the time of spraying. He found ryegrass to be more resistant to dalapon than cocksfoot, but the latter was more tolerant of autumn than summer treatments. At an assessment 3 months after spraying, Festuca rubra var. fallax appeared more resistant to these rates following the December application than was cocksfoot, while the latter appeared more resistant to the March applications. Agrostis tenuis and Holcus lanatus showed very similar tolerance to dalapon at both dates but the chemical was more effective against them in autumn than in summer. Poa trivialis was found to be even less resistant to dalapon than the above species.

Jones (1962) applied paraquat at 1.8 lb/ac plus wetter to a mixed lowland sward in April 1960. Yields were assessed in October 1960. White clover had increased by a factor of x30, cocksfoot by x4.5, and perennial ryegrass by x3, whereas yields of Agrostis stolonifera were reduced to 40% and Poa trivialis to 20% of those on unsprayed controls. Yields of dicotyledonous weeds were reduced by 50% while the other component consisting of miscellaneous grasses had increased by 1.7. Total dry matter yields of the treated plots exceeded those of the controls by 150%.

In addition Jones and David (1962) applied paraquat at 0, 0.125, 0.25 and 0.5 lb/ac on 19th April 1962 to an old ryegrass, white clover ley infested with Poa trivialis. The plots were harvested on 4th June, grazed and topped later in June and again harvested in August, September and November 1962. At first all species were suppressed by all rates of paraquat. By August the ryegrass was back to normal on plots sprayed with 0.25 lb/ac but P. trivialis had made very little recovery at this dose rate producing only 14% of the yield of this species on unsprayed control plots. Also by August white clover had increased markedly on the 0.25 lb/ac plots compared with controls.

Bramley (1961) in New Zealand investigated the tolerance of pure stand of 3 yr old Lolium perenne, Dactylis glomerata, Agrostis tenuis, Festuca rubra var. fallax and Holcus lanatus to 0.45, 0.9 and 1.8 lb/ac of paraquat applied in late December 1960, and late March 1961. The stands of ryegrass were contaminated with volunteer Poa trivialis. Applied at either date, paraquat at 0.45 lb/ac had a negligible effect on perennial ryegrass, but the 0.9 and 1.8 lb/ac rates produced increasingly severe effects as indicated by assessments made 3 months after spraying. Cocksfoot was more susceptible to 0.45 lb/ac applied at either date than was ryegrass, and March applications had more severe effects than December. At either date 1.8 lb/ac paraquat almost eliminated cocksfoot and 0.9 lb/ac gave 75% control. Agrostis tenuis was markedly more tolerant of paraquat applied in March than in December, the high rate in March giving no better control than the low rate in December. Paraquat at 0.45 lb/ac, 3 months after application in December gave 40%, 0.9 lb/ac 80% and 1.8 lb/ac about 90% reduction of Agrostis while 1.8 lb/ac was required for a 40% reduction 3 months after the March application. About 50% reduction of Festuca rubra was achieved with 0.45 lb/ac paraquat applied in December, while 0.9 and 1.8 lb/ac gave 85 and 95% control, respectively. Those rates applied in March were less effective, 0.9 lb/ac being required for about 60% reduction and 1.8 lb/ac for an 80% reduction. Holcus lanatus was reduced 95% by as little as 0.45 lb/ac applied in March, but this rate applied in December allowed 44% survival and only the high rates achieved kills comparable with the March applications. *Poa trivialis* in ryegrass plots was eliminated by all rates of paraquat applied in December and by 1.8 lb/ac applied in March. In March 0.45 lb/ac caused about 50% reduction.

References

Allen, G.P. (1963) W.R.O. internal files on experiments Ag. 1, 3, 4, 5, 13.62: AG. 3, 4.64: AG. 7, 8, 9, 10, 11, 12.65 (unpublished).

Allen, G.P. (1965) The ability of paraquat, dalapon and amitrole-T to kill an Agrostis/Lolium pasture in July, October and April. Weed Res., 5 No. 3, 237-51.

Armstrong, S.F. (1937) British grasses and their employment in agriculture. 3rd Ed. Cambridge University Press.

Baker, H.K. (1962) A Survey of English grasslands. Proc. 6th Br. Weed Control Conf., 23-30.

Blackman, G.E. (1933) Investigations on the intensive system of grassland management. XII. The influence of the grazing factor on the botanical composition of intensively managed pasture. Emp. J. exp. Agric., No. 1. 1933.

Blackman, G.E; Lewis, A.H. (1935) The growth of pastures in the spring and its relationship to available nitrogen supply and temperature. Trans. 3rd Internat. Congr. Soil Sci., 201-3.

Boeker, P. (1959) Samenauflauf aus Mist und Erde von Triebwegen und Ruheplätzen Z. Acker-u-PflBau, 1959, Vol. 108, No. 12, 77-92.

Bramley, P. (1961) New developments in the weedkiller field. Proc. 14th N.Z. Weed Control Conf., 1961, 41-47.

Caputa, J. (1956) L'hiver 1955-56. Ses doulourcuses consequences pour les cultures de Suisse romande. IV. Plant fourragères. Rev. rom. Agric. 12, No. 11, 101-3.

Carrol, J.C. (1943) Effects of drought, temperature and nitrogen on turf grasses. Pl. Physiol. 18, 19-36.

Carrol, J.C; Welton, F.A. Daily periodicity of stomata in certain species of turf grasses. Bot. Gaz., 99, 420-3.

Chippindale, H.G. (1949) Environment and germination in grass seeds. J. Br. Grassl. Soc., 4, 57-61.

Chippindale, H.G; Milton, W.E.J. (1934) On the viable seeds present in the soil beneath pastures. J. Ecol., 22, 508-31.

Clapham, A.R.; Tutin, T.G.; Warburg, E.F. (1962) Flora of the British Isles. 2nd Ed. Cambridge University Press. 1957.

Cooper, J.P.; Calder, D.M. (1964) The inductive requirements for flowering of some temperate grasses. *J. Br. Grassl. Soc.*, *19*, No.1, 6-14.

Edmond, D.B. (1964) Some effects of sheep treading on the growth of 10 pastures species. *N.Z. J. agric. Res.* *7*, No. 1, 1-16.

Evans, S.A. (1963) Summary of replies to a questionnaire sent to N.A.A.S. Regional Grassland Officers in 1962. *Proc. 2nd A.R.C. Symposium on Pasture Renovation, Jan. 1963* (Unpublished).

Goodey, T. (1941) *Anguillulina dipsaci* from 'tulip root' of oats injuring seedlings of a seeds mixture. *J. Helminth.* 19, 1-8.

Green, J.O.; Anslow, R.C.; Corrall, A.J.; David, G.L. Species, varieties and seed mixtures. *Exps. Prog. 16, Grassl. Res. Inst. 1962-63*, 19-20.

Greenfield, I. (1962) Turf Culture. Leonard Hill (Books) Ltd., London 1962.

Grassland Research Institute, Hurley. (1964) Private communication.

Harrington (1923) Use of alternating temperatures in the germination of seeds. *J. Agric. Res.*, 23, 295-333.

Hubbard, C.E. (1954) Grasses. Penguin Books.

Jones, M.G. (1933) Grassland management and its influence on the sward. Part I. Factors influencing the growth of pasture plants. *Emp. J. exp. Agric.*, No. 1, 43-57.

Jones, L. (1962) Herbicides to aid pasture renovation. *J. Br. Grassl. Soc.*, *17*, 85-86.

Jones, L. (1962) Control of grasses in established lucerne by paraquat. *Proc. 6th Br. Weed Control Conf.* 93-95.

Jones, L.; David, G.L. (1964) Herbicides. *Exps. Prog. 16, Grassl. Res. Inst.* 1962-63, 26.

Koning, H. (1957) De dorkosten van ruwbeemd in de Noordoost polder. *LandbVoorl*, *14*, No. 4, 180-2.

Laity, J. (1956) Long-term rotational pasture. *J. Br. Grassl. Soc.*, *11*, No. 2, 104-6.

Milton, W.E.J. (   ) The buried viable seeds of enclosed and unenclosed hill land. Welsh Pl. Breed. Sta. Bull. Ser. H., 14-16.

Milton, W.E.J. (1934) The relative palatability of seeds mixtures and a study of the influence of fertilisers on natural hill pastures. Emp. J. exp. Agric., 2, 51-64, 347-60.

Perring, F.H.; Walters, S.M. (Eds) Atlas of the British Flora. Thomas Nelson and Sons, Ltd.

Reyntens, H. (1949) Onderzoek betreffende de weerstand tegen overstroming van verschillends gras-en klaversoorten en waarde der grasflora in Dender-Schelde-en Durmevallei. Med. LandbHogesch., Gent., 14, 251-62.

Reyntens, H. (1952) Naast selectieve onkruidbestrijding met synthetische groeistoffen in de graaszode van weideboomgaarden, graasen hooiweiden, eveneens vernietiging van bepaalde minderwaardige grassorten langs mechanische weg. Med. LandbHogesch., Gent. 17, No. 1, 1-15.

Rhode Island State College, (1941) 53rd Annual Report of the Agric. Expt. Station. Contribution 586.

Salzmann, R. (1939) The distribution of viable seeds in farmyard manure. Schweiz. Landw. MtsHeft, No. 5, 40-4.

Sijbring, P.H. (1963) Results of some storage experiments under controlled conditions (agricultural seeds) Proc. internat. Seed Test Ass., 28, No. 4.

Sonneveld, A. (1948) Zaaidiepte en grondbewerking bij graslandinzaai (Sowing depth and tillage in sowing land to grass). Versl. Cent. Inst. Landbouwk. Onderzoek, 21-7.

Sonneveld, A. (1958) Het inzaaien van grassen en klavers (sowing grasses and clovers) Meded. 38., Inst. Biol. Scheik. Onderz LandbGew., 212-5.

Stassen, J. (1953) Beziehungen zwischen Bewirtschaftung, Obstrutzung und Zustand der Dauerweilden im Kreise Geilenkirchan-en-Heinsberg. Z. Acker-u. Pflbau. 96, No. 2, 243-60.

Stoffers, A.L.; Knapp, R. (1962) Influence of inundation on various sward associations. Ber. dtsch. bot. Ges., 75. No. 8. 280-94.

Thomas, I. (1938) On the bionomics and structure of some Dipterous larvae infesting cereals and grasses. III. Geomyza (Balioptera) tripunctata Fah., Ann. appl. Biol. 25, 181-96.

Thomas, J.O.; Davies, L.J. (1938) Common British Grasses and Legumes. Longmans, Green & Co.

Wind, Tj, Th.; Vries, D.M. de. (1954) Over het verschil in invloed tussen organische en anorganische bemesting op de botanische samenstelling van oud grasland. Versl. Cent. Inst. Landbouwk. Onderz 1954, 56-60

Volk, A. (1937) Investigations on *Typhula graminum* Karst. Z. PflKrankh, 47, 338-65.

Vries, D.M. de (1938) The recovery of grassland from drought produced damage in relation to the desirability or not of heavy applications of nitrogen. Herb. Abstr. No. 8. 1938. Page 83.

Vries, D.M. de (1940) Asexual reproduction of grasses in pastures, Landbouwk. Tijdschr., 52, 760-6.

Vries, D.M. de (1940) Effect of severe cold on turf. Landbouwk Tijdschr., 52, 320-9.

Vries, D.M. de; Hart, M.L.T. (1941) The consequences of severe frost on grassland. Nieuwe Veldbode, Nos. 31-32.

Weed Research Organisation Technical Reports

1. Susceptibility of ornamental plants to simazine and other chemicals. Trees and shrubs. November 1964. G. W. Ivens. Price - 5s. 0d.

2. 3,5-Di-iodo-4-hydroxybenzonitrile. A progress report on experimental work by the A.R.C. Weed Research Organisation. May - October, 1963. K. Holly and J. Holroyd. No charge.

3. Chemical control of bracken. 1964. G. L. Hodgson. Out of print.

4. Susceptibility of ornamental plants to simazine and other chemicals. Annuals, biennials and herbaceous perennials. April 1965. G. W. Ivens. Price 2s. 6d.

5. Not available for distribution.

6. The botany, ecology, agronomy and control of _Poa trivialis_ L. - rough-stalked meadow-grass. November 1966. G. P. Allen. Price 5s. 0d.