THE PATTERN OF WEED INVASION IN RYEGRASS PASTURE

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Summary

While much attention has been devoted to the removal of weeds from our pastures, surprisingly few references can be found in the literature to studies of the ingress of these volunteer species. A pattern of weed grass invasion in nine-year-old ryegrass pastures is described here and examined in the light of other studies of browntop (*Agrostis tenuis*) and poa trivialis (*Poa trivialis*). It is shown how a single factor, in this case a spell of exceptionally dry weather, can tip the ecological balance of a pasture and initiate a steady degeneration.

INTRODUCTION

THAT weed grasses invade sown pastures over a period of time in spite of the most careful management is well known. "The presence of these [volunteer species] is an indication of either the lack of knowledge to prevent their ingress or to effect their removal, or of their acceptance as a valuable component of the sward" (Vartha, 1965).

Sears (1960) emphasized the significance of the invasion of ryegrass/white clover pastures by poa trivialis (*Poa trivialis*). He described a mechanism leading to suppression of clover and resultant loss of nitrogen. Cooper (1962) referred to poa trivialis and browntop (*Agrostis tenuis*) as "invariable invaders of sown grassland" and listed the factors which determine the composition of a pasture as follows: (1) The inherent perenniality of the sown species; (2) soil physical conditions especially moisture; (3) soil fertility, especially phosphate, potash and nitrogen levels, and (4) management, particularly the intensity of grazing at various times of the year. To these one might add the factors of disease and insect pests.

Some detailed work has been done by Harris and Brougham (1968) in which they demonstrated the invasion of a ryegrass/white clover pasture, subjected to continuous close grazing, by browntop, *Poa* spp. and other weeds. Basing their studies on tiller populations, they constructed distribution maps and association tables (after Greig-Smith, 1957) which showed a number of clearly defined relationships between the sown and volunteer species.

In the present paper, some data are presented from a trial that has been under observation for nine years. It was originally laid down at Invermay Research Station in 1960 by N. A. Cullen as one of a national series of trials designed to assess the performance of the then new long-rotation ryegrass (now known as 'Grasslands Ariki') and compare it with the established perennial ('Grasslands Ruanui') and short-rotation ('Grasslands Manawa') ryegrasses.

EXPERIMENTAL

The trial is located on recent alluvial silt loam soil on the Taieri Plains, Otago. Average annual rainfall for the district over the period of the trial has been 26 in., with a fairly even seasonal distribution (see Table

1). The three treatments consisted of Manawa, Ariki and Ruanui ryegrass sown in separate 1/10 acre paddocks at rates of 15 lb, 18 lb and 18 lb per acre, respectively, with 3 lb of white clover, 1.5 lb of Montgomery red clover and 1.5 lb of broad red clover seed per acre. All plots received an annual topdressing of 3 cwt of superphosphate per acre for the first three years and from 1964 onwards 3 cwt of superphosphate and 1 cwt of potash per acre were applied annually. DDT was also applied occasionally, but at no time were there any marked infestations of porina caterpillar (*Wiseana* spp.) or grass grub (*Costelytra zealandica*). Each treatment had four replicates.

All treatments were grazed intermittently by sheep during the growing season; when the herbage reached a height of approximately 2 in. it was grazed down over a period of two or three days to a height of ½ to 1 in. Herbage production measurements were made using the frame and trimming technique (Lynch, 1947). Dry matter yields and herbage dissection data were collected for each cut and point analysis was done annually in the spring.

TABLE 1: MONTHLY RAINFALL (in.) — INVERMAY 1960-69

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*
Jan.	0.91	2.25	2.58	1.85	3.62	2.28	6.54	1.80	1.24	2.71
Feb.	2.90	2.84	3.03	3.35	0.58	2.65	1.15	1.71	2.30	1.19
Mar.	3.52	3.15	4.32	2.07	3.98	2.19	2.38	2.77	7.70	2.40
Apr.	1.22	2.56	1.71	1.97	1.02	1.89	0.95	2.29	10.24	1.99
May	1.10	0.86	0.99	1.32	1.28	1.95	1.35	2.44	1.19	4.04
Jun.	6.65	1.21	1.95	2.11	0.33	2.77	1.33	0.59	1.57	1.49
Jul.	0.89	3.47	2.75	2.81	2.33	1.24	1.30	0.68	1.82	0.48
Aug.	2.40	1.96	1.88	2.58	0.55	1.15	2.09	1.00	0.95	1.86
Sep.	1.26	2.61	1.23	2.93	1.11	1.22	0.56	3.52	0.99	1.98
Oct.	1.24	1.39	2.54	1.19	0.54	2.42	2.47	2.31	2.66	1.78
Nov.	3.71	2.85	2.52	1.87	1.83	3.00	1.75	2.26	1.92	1.37
Dec.	2.41	1.02	1.41	2.66	2.60	2.67	1.94	1.14	1.23	4.66
Year	28.21	26.17	26.91	26.71	19.77	25.43	23.81	22.51	33.81	25.95

RESULTS

The three treatments showed a somewhat similar pattern of changing pasture production and composition over the years although there were marked differences in degree, particularly between Manawa and Ariki (Fig. 1). Ryegrass dry matter production reached a peak in the second year (1961-2) but maximum total pasture production was not achieved until 1963-4, at which time the proportion of clover in the sward had reached a peak and yielded about 4,000 lb DM per acre with no significant differences between treatments. Total dry matter yields per acre were 13,920 lb for Manawa, 15,200 lb for Ariki and 14,620 lb for Ruanui. The difference between Manawa and Ariki was significant at the 1% level and the differences between all three were significant at the 5% level.

The year 1964 was exceptionally dry and pastures were subjected to a considerable degree of moisture stress. The area in which the trial was located contained a number of shingle bars and several plots were affected by those in the very dry spell in February and again in the spring. Dur-

ing the two years following this, the clover contribution to pasture yield declined steadily until it reached an apparently stable level of production of about 1,000 lb DM/acre per annum, which level it has maintained up to May 1969. In 1964-5 there was a rapid increase in the amount of weed grasses which, for the first four years of the trial, had played an insignificant role. A steady decline in ryegrass yields appears to have followed on the clover decline. The overall result of these various changes seems to have been a general decline of total pasture yields since 1964. The changes have been greatest in the Manawa pastures and in 1967-8 Manawa ryegrass contributed less than half of the total production while the contribution of the weed grasses was more than that of ryegrass. The salient features of these changes are shown in Table 2.

It is clear that there has been little change in the percentage contribution to dry matter production of the ryegrass component in the Ariki treatment over the main period of the trial. This is demonstrated in Table 3 in which selected spring and summer cuts are compared. The Ruanui treatment has been omitted as the pattern was similar to Ariki. The gradual disappearance from the sward of Manawa ryegrass is quite clear in this table. Although absolute yields of Ruanui and Ariki ryegrass have also declined over the same period, point analysis recorded the same number of hits on ryegrass in 1968 as in 1963. This suggests that the ryegrass

TABLE 2: TOTAL AND SPECIES YIELDS IN SELECTED YEARS
(lb dry matter/acre)

Yields of	*1961-2*	*1963-4*	*1967-8*
Ryegrass			
M	10,650 a	9,690 bA	3,810 cC
A	11,820 a	11,210 aA	8,370 aA
R	11,040 a	9,930 bA	5,580 bB
CV%	8.2	6.8	8.4
White Clover			
M	790 a	3,730 a	1,070 a
A	900 a	3,640 a	1,180 a
R	790 a	4,190 a	1,350 a
CV%	33.4	11.0	21.5
Red Clover			
M	370 a	70	—
A	320 a	60	—
R	400 a	80	—
CV%	23.5	N.A.	
Other Grasses			
M	0 a	350 a	4,480 aA
A	20 a	170 a	1,880 cB
R	20 a	340 a	2,610 bB
CV%	152.0	45.5	9.7
Total			
M	12,040 a	13,920 cB	9,900 bB
A	13,340 a	15,200 aA	11,760 aA
R	12,620 a	14,620 bAB	9,910 bB
CV%	6.5	2.1	6.0

Treatments: M = Manawa; A = Ariki; R = Ruanui.
N.A. = not analysed.

TABLE 3: HERBAGE COMPOSITION IN SPRING AND SUMMER

% of total dry matter yield on dates shown.

	Spring						
	23/10/62	*21/10/63*	*19/10/64*	*19/10/65*	*17/10/66*	*16/10/67*	*14/10/68*
Manawa							
Ryegrass	78	60	74	54	39	38	32
Clover	22	36	13	8	9	11	16
Poa annua			4	11	17	6	7
Poa trivialis		3	8	17	17	13	11
Bromus mollis			1	7	10	17	23
Browntop				1	4	6	7
Other grasses				1	1	1	2
Flatweeds		1		1	3	8	2
Ariki							
Ryegrass	88	73	86	89	82	72	82
Clover	12	24	12	3	9	10	8
Poa annua		1	1	2	2	4	2
Poa trivialis		1	1	6	5	7	4
Bromus mollis					1	1	1
Browntop						3	2
Other grasses					1	1	1
Flatweeds		1				2	

	Summer						
	14/1/63	*20/1/64*	*18/1/65*	*4/1/66*	*16/1/67*	*10/1/68*	*20/1/69*
Manawa							
Ryegrass	60	69	49	52	44	32	23
Clover	40	29	33	13	15	10	20
Poa annua			2	7	6	2	3
Poa trivialis		1	3	10	7	3	3
Bromus mollis		1	10	15	22	46	44
Browntop					1	3	3
Other grasses				1	1	3	1
Flatweeds			3	2	4	1	3
Ariki							
Ryegrass	69	74	56	74	79	66	65
Clover	31	26	40	12	10	14	22
Poa annua			1	5	3	5	3
Poa trivialis			1	5	4	4	2
Bromus mollis			1	3	3	5	7
Browntop						2	
Other grasses							
Flatweeds			1	1	1	4	1

Other grasses include cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*), crested dogstail, sweet vernal (*Anthoxanthum odoratum*), Yorkshire fog (*Holcus lanatus*).
Flatweeds include mainly annual mouse-eared chickweed (*Cerastium glomeratum*), also daisy (*Bellis perennis*), Scotch thistle (*Cirsium vulgare*), hawksbeard (*Crepis capillaris*), hawkbit (*Leontodon taraxacoides*), dandelion (*Taraxacum officinale*).

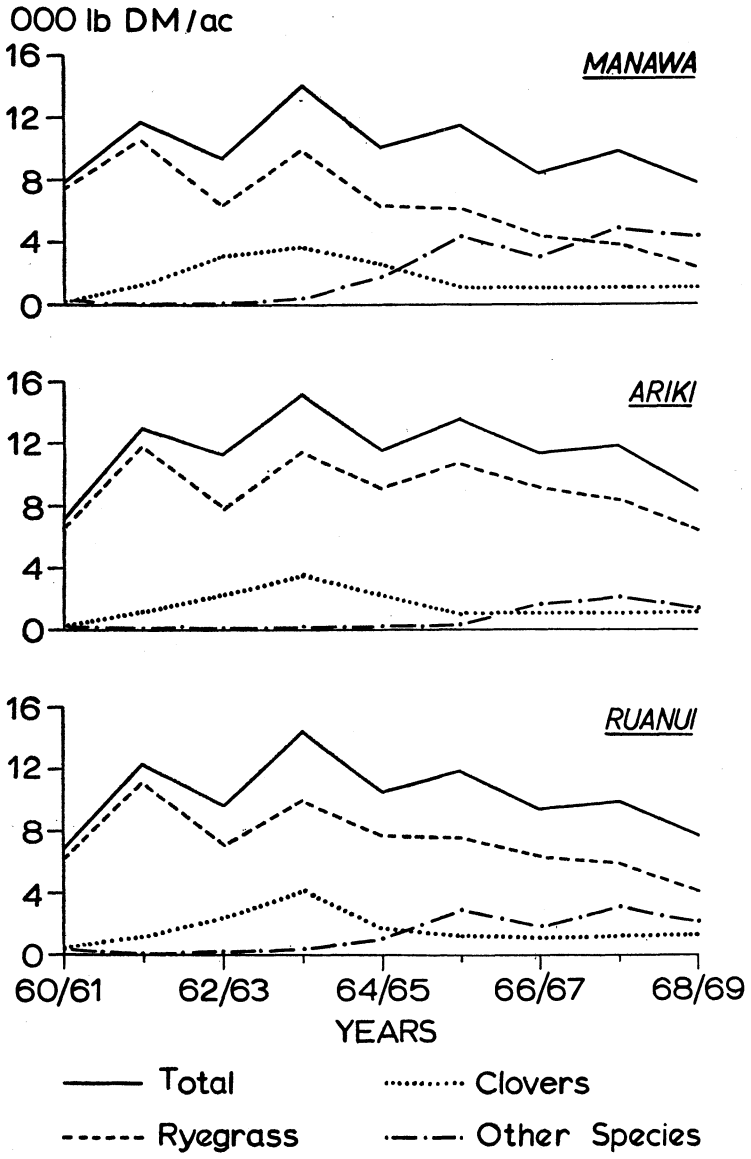

FIG. 1: *Annual dry matter production, 1960-69.*

plants which survived the dry conditions of 1964 and persisted in the face of subsequent competition from weed grasses were ecotypes which tillered vigorously but did not experience so much vertical vegetative growth. On the other hand, they may simply have been smaller, weaker and less productive plants. Unfortunately, no tiller count data are available so this hypothesis cannot be checked.

All the weed grasses forming a significant component of the sward in 1967-8 were — with the exception of crested dogstail (*Cynosurus cristatus*) — present in small numbers in 1963. Poa trivialis was the first weed grass to make a measurable contribution to dry matter production. By 1965 its contribution had reached significant proportions and it had been joined by poa annua (*Poa annua*), bromus mollis (*Bromus mollis*) and browntop in the Manawa treatment. In the summer of 1968, bromus mollis contributed 46% of the dry matter producion of Manawa swards at one cut, outyielding all other species in the sward. At the same cut on the Ariki swards *Poa* spp., bromus mollis and browntop taken together achieved only 16% of total production. Point analysis in 1968 recorded 25 hits per 100 points on *Poa* spp. in Ariki plots. In the 1968-9 season, Manawa swards produced little more than half the total dry matter that they had produced in 1963-4 and over half of this was from weed grasses, mainly bromus mollis but also significant quantities of browntop and *Poa* spp. Ariki swards in 1968-9 yielded 59% of their 1963-4 production but only 13% of this was contributed by weed grasses.

DISCUSSION

Vartha (1965) suggested that New Zealand's pastoral agriculture appeared to be based on the assumption that sown ryegrass/clover associations are the basis for maximum herbage productivity and stock carrying capacity. This assumption seems to have been made with very little empirical evidence to support it.

Statistical analysis of the production data showed a significant negative regression from the fourth to ninth years of the trial. In other words, a significant decline in pasture production was initiated, probably by the dry spell, in 1964. Analysis of data from a number of other trials at Invermay (R. S. Scott, pers. comm.) indicated a positive trend of production for young pastures and a negative trend for old pastures — *i.e,* production of sown pastures under good management increases for the first three or four years and thereafter starts to decline. This decline could be due to a number of factors working singly or in combination. Nitrogen status may have fallen owing to insufficient rhizobial activity, fertility may be low as a result of inadequate topdressing with phosphate or potash, disease or insect pests may have attacked the pasture, soil physical conditions may have deteriorated (for example, as a result of inadequate drainage) and, finally, high yielding species may have been replaced by low yielding species. This last event is the inevitable by-product of any of the others. A sown ryegrass/clover pasture is an unstable ecosystem which has to be artificially maintained. It requires only a small jolt to start a decline and once started it will continue until it reaches a new equilibrium.

It seems fairly certain that, in the case under discussion, the "jolt" was in the form of an exceptionally dry period in 1964. Most other possibilities can be eliminated; topdressing was adequate and there was no evidence of phosphate or potash deficiencies, there were no major attacks of disease or insect pests, drainage was adequate. The cause of the clover

decline is not clear but it would seem, at least in part, to have something to do with competition from grasses. In the summer of 1965, there was a high proportion of clover in the sward, but this was only a short-lived effect due to the considerably weakened ryegrass component resulting from the very dry spring. Weed grasses gained a foothold in the sward opened up by the dry conditions and poa trivialis probably began to compete with clover, particularly in spring.

In two short-term experiments, Vartha (1965) was not able to find any marked effect on total herbage yields as a result of including poa trivialis in a ryegrass/clover sward although significant changes in botanical composition, evidenced by reduced ryegrass and clover yields, did take place. Although the growth patterns of poa trivialis and clover appeared to be more or less complementary, competition from poa trivialis reduced yields of clover and ryegrass at certain times of the year. Vartha considered that the full effects of reduced clover yields were probably not recorded as the trials were of limited duration and nitrogen was applied in one case. The evidence for an inverse relationship between poa trivialis and clover in the present trial is not strong but there does seem to be some indication of such an effect. It has not been possible to determine whether or not the decrease in clover yields has been matched by a significant decrease in nitrogen status of the soil sufficient to reduce grass yields.

Harris and Brougham (1968) observed a positive association of poa trivialis with white clover which they linked with an observed preference on the part of poa trivialis for high nitrogen sites. The behaviour of poa trivialis in this instance would seem to be self-destructive since, by suppressing clover in competition, it will eventually lower the nitrogen status of the soil.

The explanation put forward by Harris and Brougham for the higher browntop content of Manawa pastures as compared with Ariki or Ruanui does not seem to apply in the present case. They suggested that Manawa, by its vigorous early growth, would suppress clover and thus lower the nitrogen status of the soil. The known susceptibility of Manawa to overgrazing could result in a more rapid opening of the sward. The resultant low nitrogen spaces would be favourable to the establishment of browntop. There is no evidence that Manawa ryegrass suppressed clover in the early stages of this trial, though it is possible that grazing hastened the decline of ryegrass and aggravated the situation induced by drought. Browntop was not the first weed grass to appear, though it is true that it did eventually reach higher concentrations in the Manawa swards than in the Ariki or Ruanui swards. No detailed quadrat mapping was done, but eye observations show that paddocks certainly contain browntop patches similar to those described by Harris and Brougham.

About the ecology of the other major weed species, bromus mollis, little is known. Although it is a very common volunteer in sown pastures, nothing more than incidental references to it have been found in the literature. It has attained a dominant position in the Manawa pastures of this trial and obviously warrants more study in the future.

In conclusion, the pattern of weed invasion described here, and the associated changes in pasture yield and clover content, is extremely complex. It has not been possible to advance a convincing explanation for all the changes that have taken place. It seems fairly clear that the initial disruptive influence was a climatological one. Some evidence points to a subsequent lowering of fertility, other evidence suggests that plant competition was the dominant process. Yet another factor may be the frequency of defoliation (approximately at fortnightly intervals) which would tend

to suppress total pasture yields and encourage the propagation of low growing and vigorously tillering species and ecotypes rather than erect, high-yielding species.

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