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PATTERNS OF EMERGENCE OF SEVERAL IMPORTANT ARABLE WEED SPECIES

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Summary Data from three experiments on patterns of weed emergence carried out on the Institute farm during 1965, 1966 and 1967 are presented in the form of monthly emergence tables for 15 annual and 3 perennial weed species. Comparison is made between different sites in the same year and between two consecutive years on the same site. Considerable variation was experienced both in numbers of weeds emerged and in periodicity of emergence. This was attributed mainly to the previous cropping history of the fields involved in 1965 experiments and to seasonal weather differences in 1966 and 1967 in the third experiment. The extent of the differences caused by these factors at one station may preclude comparisons between stations other than under controlled conditions. The seasonal emergence patterns of the various weed species are discussed in terms of the weed problems of crops sown or planted between March and October.

INTRODUCTION

An aspect of the interrelation between crops and weeds that has received little attention from research workers is the effect of climatic variation throughout the United Kingdom on the relative times of emergence and early growth patterns of crops and their associated weeds. The need to vary weed control techniques to take account of field-to-field and regional differences in associations of weed species is self-evident. Whether or not there is also a need for variations in herbicide treatment to cater for differences in the relative competitive ability of crop and weeds under different climatic conditions is a much more complex problem. Roberts (1964) and Chancellor (1965) examined patterns of emergence of annual weeds in the field over many years at Wellesbourne and Oxford respectively. They found considerable year-to-year variation but were able to establish the main germination periods of many important species and to group them according to seasonal behaviour characteristics. From this information they forecast the likely weed species to be encountered in different crops, or as a result of different sowing dates of the same crop, for their particular localities. The experiments reported in this paper were carried out to provide information on the weed flora at Mylnefield and to give some indication of whether or not the seasonal behaviour of individual species differed from that recorded over 300 miles to the south.

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MATERIALS AND METHODS

The experiments were carried out on the Institute farm over the period 1965-67. In 1965 two similar experiments were laid out, some 800 metres apart, one in Mid Loan field (Expt.I) and the other in South Bullion field (Expt.II). Each experiment comprised 6 replicates of 30 plots laid out in a randomised block design. Individual plots were $1m^2$ in area with guard strips of 0.5m and 1m separating plots and blocks respectively. Treatment involved 30 dates of digging individual plots between March 10 and October 6, with approximately 7 day intervals between treatments. Each plot was dug over thoroughly once only to a depth of 23cm using a sharp spade. The soil was then reduced to a rough seedbed by breaking up lumps with the back of a fork. Three weeks later a count was made of all the annual weed seedlings present on the whole plot area. Both sites were as far as possible given identical treatment. Weeds growing on hitherto undug plots or on those where recording had finished were controlled by occasional spraying with paraquat.

Experiment III was laid out in 1966 in West Loan field, 75 metres from the site of Expt. I. In this case there were 6 replicates of 12 plots laid out in a randomised block design. Plot size was $3.3m^2$ with guard areas of 0.3m and 1m width separating plots and blocks respectively. Treatment involved 12 dates of single digging, corresponding to the beginning of each calendar month throughout the year. Digging and seedbed preparation were carried out as described for the 1965 experiments, but weed counts were not made until the end of each month. Weed counts were continued on already-dug plots at monthly intervals round the year to allow assessment of weed emergence on undisturbed as well as on cultivated plots. The experiment was continued for a second year, with each plot being dug again on the anniversary of its original treatment. Monthly recording of weed numbers and species continued until the end of December 1967. Plots due for treatment in early January and February 1966 could not be dug due to hard frost. Experimental treatments commenced therefore with the plots dug on March 2. Winter digging treatments in the second year were not obstructed by frost. During 1966, plots not yet due for digging were kept clean by regular treatment with paraquat, which was also applied to dug plots after every monthly count except during the winter months when weeds were few.

Records of rainfall and accumulated day degrees over 5.6°C (based on screened air temperatures) for the three year period were obtained from the Institute agro-meteorological station which is situated approximately half-way between the site of Expt.II and those of the other two experiments.

The soil in South Bullion field is classified as a sandy clay loam with an organic matter content, as determined by loss on ignition, of 8%. Mid Loan and West Loan fields have slightly lighter soils, classed as sandy loams, with an organic matter of 6.7%.

The previous cropping history of each field was as follows:

Site	Mid Loan	S. Bullion	West Loan
Expt.	I	II	III
1965	-	-	Potatoes
1964	Swede turnips	Sugar beet	Spring barley
1963	Blackcurrants	Winter wheat	Spring barley
1962	Blackcurrants	Grass	Spring barley
1961	Blackcurrants	Spring barley	Carrots
1960	Blackcurrants	Vegetable Expts.	Spring barley

MCPA was applied to all the cereal crops mentioned above, but otherwise weed control was solely by cultivation.

The following abbreviations have been used in the Tables to denote individual weed species.

S.v.	Senecio vulgaris	L.a.	Lamium amplexicaule
P.av.	Polygonum aviculare	F.o.	Fumaria officinalis
S.m.	Stellaria media	P.an.	Poa annua
C.al.	Chenopodium album	V.h.	Veronica hederifolia
V.p.	Veronica persica	C.b-p.	Capsella bursa-pastoris
G.t.	Galeopsis tetrahit	S.a.	Spergula arvensis
P.co.	Polygonum convolvulus	U.u.	Urtica urens
A.p.	Atriplex patula	T.f.	Tussilago farfara
C.ar.	Cirsium arvense	M.spp.	Mentha species

RESULTS

Data from each of the three experiments have been summarized in the form of weed emergence records per calendar month. The species represented in Tables 1-3 constituted over 97% of the total numbers of weeds recorded. Monthly rainfall and accumulated temperature records for the three year period are shown in Fig.1.

Expts. I and II

Spring temperatures in 1965 were near average but the period July-September was cooler than usual. Rainfall was well below average in February, March and April but above average from May to July. February was by far the driest month of the year and September the wettest. Little or no weed emergence occurred before mid-April on either site.

Although both experiments produced very similar total numbers of weeds over the year and all weed species, apart from Spergula arvensis were represented at both sites, the relative proportions of each species in the total flora were markedly different (Table 1). In Expt.II Poa annua contributed 75% of the total population with Stellaria media the next most numerous species at 7.5%. By contrast Expt. I was dominated by S. arvensis (30%) and S. media (22%) with P.annua, Fumaria officinalis and Atriplex patula contributing 9, 8 and 7% each respectively. Eight times as many seedlings of P. annua were recorded in Expt. II as in Expt. I, whereas with the exception of Chenopodium album, all other species were more numerous in Expt. I.

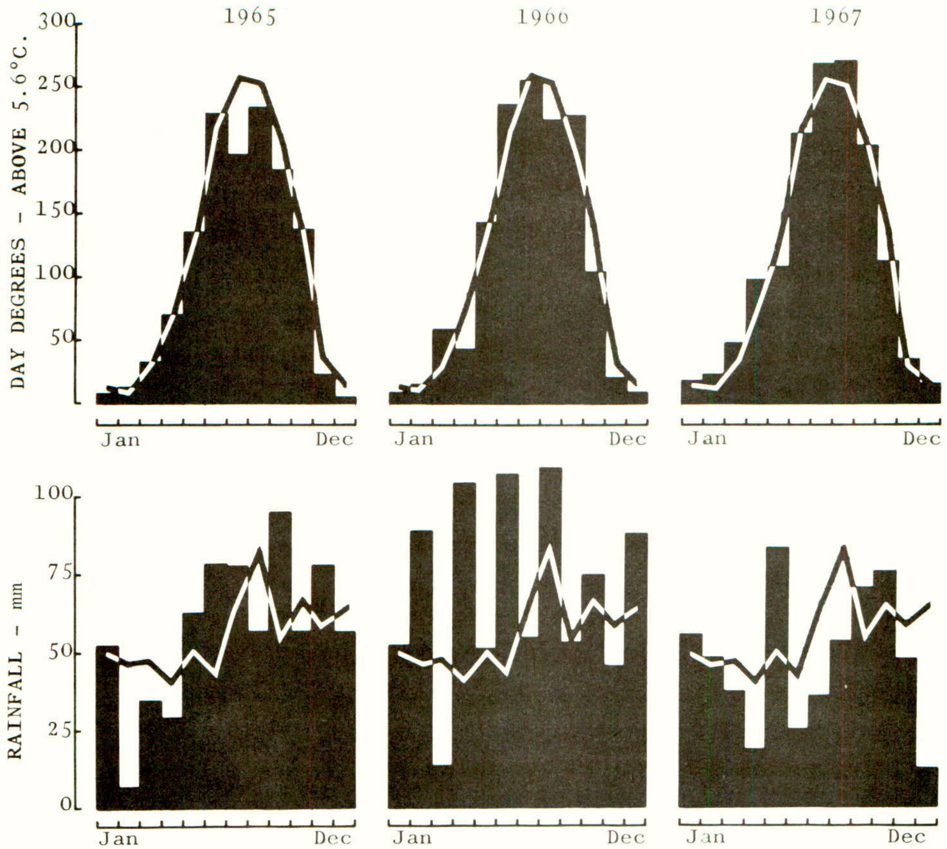

Fig.1. Monthly distribution of a) accumulated day degrees, b) rainfall, together with long term averages

In terms of total numbers of seedlings recorded, peak emergence occurred in August in Expt. I and in June in Expt. II while monthly totals (excluding March) were higher in Expt. I for every month except May and June. Fig. 2a shows monthly emergence between March and October as a percentage of total emergence for species well represented at both sites. For P. annua, S. media, Veronica persica, Lamium amplexicaule and A. patula, peak emergence occurred in June in Expt. II compared with August or September in Expt. I. Polygonum aviculare and C. album, however, produced their highest numbers in the same months at both sites. These variations between the two sites, together with the differences in numbers of any one species, produced marked differences in the monthly composition of the weed flora and hence in the potential requirements for effective overall weed control.

Table 1

Monthly weed emergence records 1965

Mean no. of seedlings per $10m^2$ area

Weed	Expt.I - Mid Loan Field									Expt.II - South Bullion Field								
	Weeds emerged during the month of																	
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
S.v.	0	0	0	5	2	34	14	0	55	0	0	2	13	7	4	1	0	27
L.a.	0	8	29	14	60	63	42	15	231	0	3	19	37	25	9	4	0	97
P.av.	0	28	13	11	4	4	1	0	61	0	22	11	15	1	0	0	0	49
F.o.	0	164	120	85	67	51	13	0	500	0	5	6	2	1	1	0	0	15
S.m.	0	12	47	120	220	351	296	300	1346	0	44	86	164	82	19	19	22	436
P.an.	0	4	5	37	49	123	217	115	550	0	168	353	1459	707	539	733	477	4436
C.al.	0	18	76	27	12	0	0	0	133	0	1	196	9	0	0	0	0	206
V.h.	0	20	19	0	0	2	16	2	59	0	20	20	4	0	1	3	6	54
V.p.	0	0	3	33	68	130	63	29	326	0	0	25	105	72	47	18	6	273
C.b-p.	0	2	7	40	25	30	15	1	120	0	2	5	13	4	2	1	0	27
G.t.	0	1	25	62	22	5	3	7	125	0	4	4	2	2	0	0	0	12
S.a.	0	79	310	423	300	304	230	169	1815	0	0	0	0	0	0	0	0	0
P.co.	0	78	50	45	17	7	2	0	199	0	1	2	1	2	0	0	0	6
U.u.	0	3	11	42	27	15	6	2	106	0	1	16	19	1	0	0	0	37
A.p.	0	1	15	111	95	125	68	11	426	0	0	35	106	50	14	5	0	210
Total	0	418	730	1055	968	1244	986	651	6052	0	271	780	1949	954	636	784	511	5885

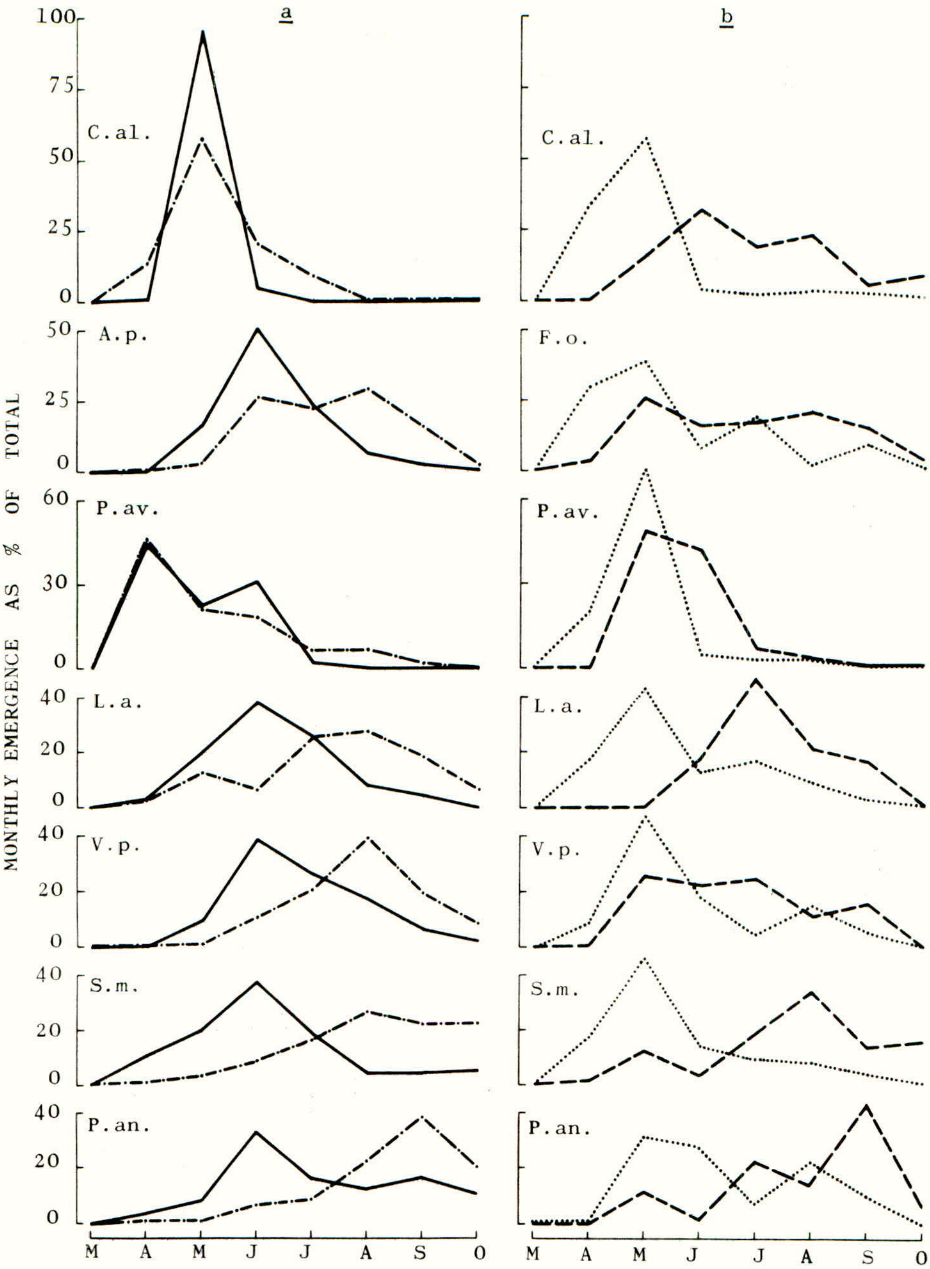

Fig.2. Monthly distribution of emergence as % of total Mar.-Oct.
a) Expt.I 1965 (—·—) and Expt.II 1965 (——)
b) Expt.III 1966 (·········) and Expt.III 1967 (– – –)

Expt. III

The weather of 1966, with the exception of March, May and July, was wet and dull. March was the driest month, but April was cooler, and as was June, very much wetter than average. By contrast, 1967 was, with the exceptions of May and October, warmer than usual. May was the wettest month of the year, but with rainfall well below average in April, June, July, August and December, the year finished with only two thirds of the total rainfall recorded in 1966 (Fig. 1).

Table 2 shows monthly weed emergence records for both years, expressed in terms of annual weed seedlings which emerged on plots dug a) within the last 3 months and b) 3-12 months previously. Data were divided into these categories to permit assessment of the effects on emergence of relatively recent soil disturbance. Even in the absence of data for January and February 1966, the total weed emergence and that of individual species within 3 months of soil disturbance was much greater in 1966 than in 1967. In 1966 68% of the total emergence on these plots occurred in April and May, while July and August accounted for 40% in 1967, with very little overall emergence before May. Over the period March-December 1966, the major species were C. album (28%) and S. media (21%), with P. annua, V. persica, F. officinalis and P. aviculare contributing 13%, 9%, 8% and 6% respectively to the overall totals. In 1967, S. media was the major species at 24%, followed by C. album (16%), F. officinalis (15%), P. annua (12%), L. amplexicaule (11%) and V. persica (10%).

Fig. 2b shows the monthly emergence of weeds between March and October as a percentage of total emergence for species well represented in both years. The data is taken only from plots dug within the previous 3 months. With the exception of Senecio vulgaris and Veronica hederifolia, all species in 1966 showed peak monthly emergence in May. In 1967 P. aviculare, F. officinalis and V. persica showed peak emergence at approximately the same time as in 1966 while C. album was only slightly later in 1967. All four species had a wider spread of emergence in the second year. In contrast, L. amplexicaule, S. media and P. annua showed peak emergence much later in 1967 than in 1966. V. hederifolia showed considerable emergence in spring 1966, but otherwise behaved as a mainly winter-germinating species. Differences in numbers and seasonal distribution between the two years in this experiment produced variations in the monthly composition of the weed flora to which crops sown at similar dates in each year would have been exposed.

Comparison of monthly weed emergence in both years on plots which had remained undisturbed for at least 3 months beforehand is limited to the period from June until December. Total weed counts during this time were greater in 1966 than 1967 (Table 2). This also applied to all species, with the exception of F. officinalis. S. vulgaris made up 27% of the total numbers produced between May and December in 1966, followed by P. annua (18%), V. persica (13%), V. hederifolia (12%) and P. aviculare (10%). In 1967 the main species were P. annua (14%), S. media (12%), V. hederifolia (10%) and V. persica (9%).

Comparison of emergence patterns on the recently dug (a) and undisturbed (b) plots from June 1966 onwards shows that for most species there was no obvious effect of cultivation on period of

Table 2

<u>Monthly weed emergence records 1966-67</u>

Mean no. of seedlings per $10m^2$ area

Weed	*	1966 Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1967 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S.v.	a)	0	2	39	10	41	38	33	0	6	0	5	0	1	2	39	1	5	0	1	0	0	0
	b)	-	-	-	4	88	17	22	0	1	0	1	0	4	1	38	1	3	0	0	0	0	0
L.a.	a)	0	52	122	37	49	29	6	0	2	0	0	0	0	0	0	38	99	44	35	1	0	0
	b)	-	-	-	4	13	6	3	0	0	0	0	0	1	0	0	7	5	5	2	0	0	0
P.av.	a)	0	60	214	14	8	6	0	1	0	0	0	0	0	0	14	12	2	1	0	0	0	0
	b)	-	-	-	32	0	17	1	0	0	0	0	0	0	0	9	1	0	0	0	0	0	0
F.o.	a)	0	108	131	29	68	4	30	0	0	0	1	0	1	11	75	44	49	60	41	9	0	0
	b)	-	-	-	4	0	0	1	1	0	0	1	5	16	4	41	3	3	4	5	1	0	0
S.m.	a)	0	178	481	151	98	89	23	10	0	0	1	0	0	6	58	18	88	159	65	72	0	0
	b)	-	-	-	11	21	6	6	0	0	0	0	0	1	1	11	3	7	6	12	8	0	0
P. an.	a)	0	6	203	177	47	144	67	3	4	0	0	0	0	0	26	4	53	33	101	15	0	0
	b)	-	-	-	18	17	44	8	1	1	0	0	1	17	0	37	2	15	9	15	1	0	0
C.al.	a)	0	466	775	49	18	30	25	0	0	0	0	0	0	0	51	101	58	71	15	24	0	0
	b)	-	-	-	4	18	0	1	0	0	0	0	0	0	0	5	10	3	0	1	1	0	0
V.h.	a)	0	106	56	2	0	0	1	4	16	5	33	2	7	11	7	5	0	0	0	0	42	11
	b)	-	-	-	4	0	0	3	6	22	22	43	2	18	2	1	0	0	0	0	0	18	12
V.p.	a)	0	39	209	78	21	65	24	1	0	0	1	0	0	1	49	42	47	22	29	0	0	0
	b)	-	-	-	11	9	18	25	0	0	0	0	0	0	0	10	9	12	4	3	0	0	0
P.co.	a)	0	16	78	24	5	0	0	1	0	0	0	0	0	0	7	19	1	1	8	3	0	0
	b)	-	-	-	0	0	1	0	0	0	0	0	0	1	0	7	0	0	0	0	0	0	0
Total	a)	0	1033	2308	571	355	405	209	20	28	5	41	2	9	31	326	284	402	391	295	124	42	11
	b)	-	-	-	92	166	109	70	8	24	22	45	8	58	8	159	36	48	28	38	11	18	12

Weeds emerged during the month of

* a) Emergence 0-3 months after digging
b) Emergence 4-12 months after digging

Table 3

Monthly emergence of perennial weed species. 1966-67

Total shoots per $10m^2$ area

Weed		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966													
T.f.	*a)	-	-	0	4	227	62	67	56	42	2	0	0
	b)	-	-	-	-	-	39	90	80	44	2	0	0
C.ar.	a)	-	-	0	0	10	18	34	5	4	0	0	0
	b)	-	-	-	-	-	18	2	4	6	0	0	0
M.spp.	a)	-	-	0	0	7	32	29	2	0	0	0	0
	b)	-	-	-	-	-	36	11	0	1	0	0	0
Total	a)	-	-	0	4	240	112	130	63	46	2	0	0
	b)	-	-	-	-	-	93	103	84	51	2	0	0
1967													
T.f.	a)	0	0	8	59	136	62	4	1	1	0	0	0
	b)	0	3	59	73	113	40	6	1	0	0	0	0
C.ar.	a)	0	0	0	3	1	7	1	0	0	0	0	0
	b)	0	0	2	7	9	5	1	0	0	0	0	0
M.spp.	a)	0	0	0	0	6	4	6	11	1	0	0	0
	b)	0	0	0	0	9	15	1	0	0	0	0	0
Total	a)	0	0	8	62	143	73	11	12	2	0	0	0
	b)	0	3	61	80	131	60	8	1	0	0	0	0

*a) Emergence 0-3 months after digging
b) Emergence 4-12 months after digging

emergence but that numbers were much reduced when the plots had remained undisturbed for at least 3 months. However, S. vulgaris and V. hederifolia showed no effect on either numbers produced or pattern of emergence. The latter species germinated mainly between November and February in either situation. F. officinalis, although its numbers were also lower on undisturbed plots gave evidence of earlier emergence under those conditions in 1967.

Perennial weeds were present on the experimental area and shoot emergence was recorded at the same time as the monthly count of annual weed seedlings. Three species occurred sufficiently regularly to allow assessment of their seasonal behaviour (Table 3). Shoot emergence counts for all three species were considerably higher in 1966 than in 1967 over comparable periods on recently dug and undisturbed plots. While the weather patterns of the two years may have contributed to differences in shoot numbers, it is also likely that as the experiment progressed there may have been some cumulative effect of regular applications of paraquat.

On plots dug within 3 months of assessment, Tussilago farfara produced its greatest number of shoots in May in both years. However, emergence continued later into the autumn in 1966 than in 1967.

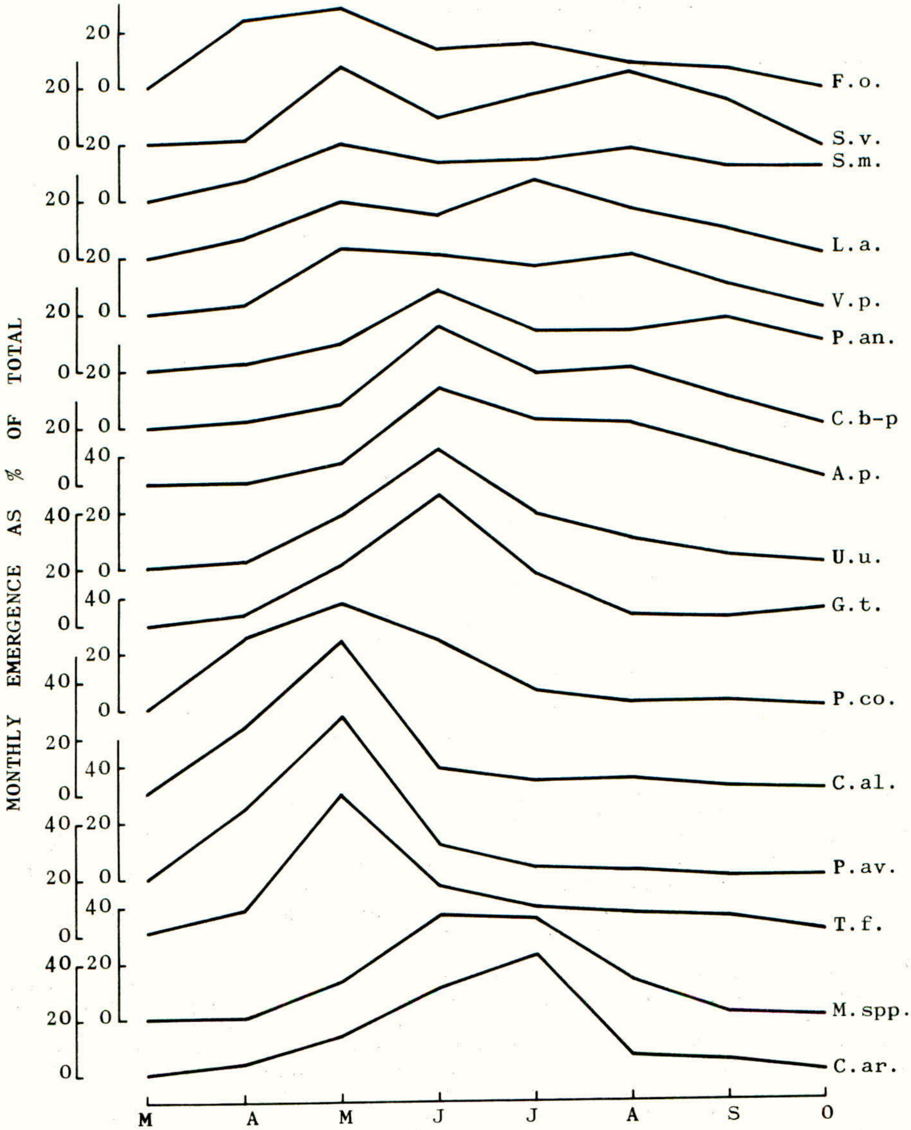

Fig. 3. Monthly distribution of emergence as % of total Mar.-Oct. based on all available data 1965-67.

Spring emergence occurred slightly earlier in 1967 on undisturbed plots but there was no indication of differences due to the timing of digging at other times of the year. Cirsium arvense emerged earlier in 1967 than in 1966 on plots dug within the last 3 months but the period of emergence was more prolonged in the first year. Mentha spp (mainly M. arvensis) showed no variation in monthly emergence dates in either year. However for both species there was evidence that emergence occurred slightly earlier in 1967 on plots undisturbed during the previous 3 months.

Seasonal emergence patterns at Mylnefield

No published information is available on the seasonal patterns of emergence of arable weeds in Scotland. For the purposes of this Symposium, all the comparable data on the species present in these experiments have been compiled to show monthly emergence as a percentage of the total emergence of that species over the period March - October inclusive (Fig. 3). Data from Expt. III for plots which had been dug more than three months prior to emergence have not been included. For most annual species the data represent the mean of both 1965 experiments and both years of Expt. III. For Galeopsis tetrahit, Atriplex patula, U. urens and Capsella bursa-pastoris adequate data are available from the 1965 experiments only while the perennial species occurred only at the site of Expt. III. V. hederifolia has been omitted because of the exclusion of its peak emergence season and Spergula arvensis because it emerged in quantity in every month from April to October at the one site where it occurred.

S. vulgaris, L. amplexicaule, S. media, P. annua, V. persica and C. bursa-pastoris showed an ability to germinate in any month from April to October, and could produce large numbers of seedlings in both late spring and late summer. Polygonum convolvulus, P. aviculare and C. album showed marked peaks in spring, while G. tetrahit and U. urens produced maximum numbers slightly later. F. officinalis and A. patula emerged in greatest numbers in spring and early summer respectively, but were capable of sustained germination for most of the growing season. T.farfara peaked very sharply in May, with the other two perennial species showing greatest emergence in June and July.

DISCUSSION

Variations in weed numbers and emergence periods

Roberts (1964) found considerable variation in emergence patterns between years as a result of differences in temperature and rainfall. The rainfall totals for the three years 1965-67 at Mylnefield and the distribution within each year were very different and all of them showed marked deviation in monthly distribution from the long term average. Weather/site/treatment interactions make it difficult to apportion responsibility for overall variations in weed growth across the experiments as a whole, but it is possible to examine the data in two distinct groupings.

In 1965, weather and treatment were constant and differences in weed emergence and frequency may largely be attributed to variation between sites. Expt. II was on a slightly heavier soil than Expt. I and differing micro-climates may have affected germination, but this is unlikely to be a major reason for the large differences in species numbers and distribution of emergence. The previous cropping history of each site and the consequent variation in the timing and frequency of weed control operations may have been an important contributory factor (Roberts, 1958). The site of Expt. I (see Materials & Methods) had been cropped with swede turnips in 1964 following the termination of a long term blackcurrant plantation. Farm records show that the blackcurrant plantation was cultivated for weed control several times each year between late winter and the onset of fruit harvesting. Thereafter no weed control operations were carried out until the following March. Herbicides were not used and although spring germinating weeds were killed by cultivation, those species capable of summer and autumn germination were allowed to grow undisturbed. It is therefore reasonable to suggest that at this site there may have been some selection within species in favour of seeds which could not only germinate from mid-summer onwards but produce plants capable of flowering and seeding before the end of the growing season.

The emergence pattern for Expt. I (Fig. 2a) is consistent for most species and in particular those capable of germinating over a large part of the growing season. It contrasts markedly with the pattern for those same species in Expt. II where the arable rotation involved seedbed preparation, soil disturbance and weed control at a wide range of frequencies and times of year, thereby avoiding selection for particular times of germination. There may however have been selection in favour of certain species, e.g. P. annua, able to germinate at most times during the growing season and not controlled by the MCPA applied to the cereal crops. If this reasoning is valid, then fluctuations in both numbers of species and their periodicity of emergence between fields may be at least as much related to cropping history as to weather and location.

In Expt. III, the site and treatment were constant and the major variables were the weather over the two years and the numbers of viable weed seeds in the soil. Decreases in the numbers of seedlings emerging in the second year of similar experiments have been reported by Roberts and Dawkins (1967), because of depletion in the weed seed reserves in the soil and this was probably largely responsible for the lower numbers recorded in Expt. III in 1967. Differences in time of emergence throughout the year and the percentage contribution of a species in particular months must have been determined to a large extent by changing weather conditions. Dry seed-bed conditions after cultivation, particularly in spring 1969, may have delayed or even prevented the germination of species with distinct spring emergence patterns, whereas those capable of emergence over most of the growing season could take advantage of favourable conditions as and when they occurred (Fig. 2b). Year-to-year variations in weather may therefore be as important as location or cropping history in determining differences in periodicity and species numbers.

Weed emergence on plots dug 0-3 months prior to assessment was considerably greater in most months and for most species than on plots dug 4-12 months beforehand. These species therefore fitted into the Arable Response Group postulated by Chancellor (1964, 1965). Numbers of seedlings of S. vulgaris and V. hederifolia were, however, relatively unaffected by recent cultivation. F. officinalis emerged earlier in the year on undisturbed plots than on those dug during the winter, but showed a positive response to recent cultivation later in the year. The timing and frequency of soil disturbance is therefore a third factor contributing to variations in weed emergence and numbers.

The perennial species were relatively little affected by seasonal differences in weather or, during summer and autumn, by the time interval since digging. Spring emergence of T. farfara and C. arvense may, however, have been adversely affected by cultivation during the winter.

Seasonal distribution of emergence of species

It must be stressed that the results shown in Fig. 3 are based on data recorded over a very restricted number of sites and years. However, general comparisons against longer term evidence by Roberts (1964), Roberts & Feast (1970) and the diagrams of Fryer & Evans (1968) suggest that the overall patterns indicated for Mylnefield are in accordance with behaviour elsewhere in Britain for many of the annual species involved. V. hederifolia, which is not shown in Fig. 2 germinated mainly over the winter months, as it does further south. The emergence pattern suggested for G. tetrahit in Fryer & Evans (1968) bears no resemblance to its behaviour in Scotland either at Mylnefield or in farm crops generally. However, unpublished data from Wellesbourne (Roberts, personal communication) agrees generally with Scottish data. The absence of published information on the emergence patterns of the 3 perennial species under arable conditions prevents comparison with other locations.

Fig. 3 is useful for comparisons of the behaviour of individual species at Mylnefield. It would not however be realistic to attempt any detailed comparisons of seasonal emergence with longer term averages produced by Roberts and his colleagues at Wellesbourne, for the following reasons

a) Data from these Mylnefield experiments are not adequately representative of potential germination in the early part of the year, since in 3 out of 4 situations the experiments did not commence until March. For this month and for October the time available for germination after digging in 1965 was too short to allow maximum germination. The 8 month curves produced for Mylnefield are also not strictly comparable with the 12 month curves for Wellesbourne.

b) The soil disturbance regimes at the two locations were different. The cultivation techniques at Wellesbourne favoured early germination with relatively early peak emergence and few late season weeds. Single annual disturbance at Mylnefield tended to enforce dormancy until the time of digging, thus delaying peak germination and prolonging the emergence period of most species. Roberts (personal communication) has suggested that this factor may be of particular importance in those species which have specific requirements for germination in the spring.

c) The variation between seasons and sites at Mylnefield was so marked that further evidence collected over a much longer time scale is required before realistic averages can be established.

Examination of weather records at Wellesbourne (from Annual Reports) shows just as marked fluctuation in spring weather from year to year as was experienced at Mylnefield. It may well be therefore that the range of variation in early spring weather at each station is greater than the difference between them. Certainly the range of germination in the four situations involved at Mylnefield (Fig. 2) was at least as great as any apparent difference between the means of those data and the data from Wellesbourne. Detailed investigation over many years would be required in order to establish which, if any, of the factors discussed had the over-riding effect at each location. In addition it would be necessary to attempt to standardize soil type, previous management and the weed seed bank, possibly by transferring soil between stations.

Crop/weed associations

The relative importance of particular constituents of a weed flora depends very much on the crop, the time of year at which it is sown or planted and the weed spectra of the available herbicides. Most weed surveys have been carried out in cereal crops, but the weed associations found in cereals need not accurately reflect the importance of the constituents of the weed flora of a soil or region in terms of other crop groups. Many different crops are grown every year at Mylnefield and it is possible to compare the monthly weed emergence data from 1965-67 with records compiled over the last 8 years of the weed problems regularly encountered with a wide range of crop types and sowing dates. Spring barley is normally drilled in the second week in March and may encounter all of the species recorded as emerging during March and April. The flora tends to be dominated by, and herbicide treatments aimed at, S. media, P. aviculare, S. arvensis, P. convolvulus, F. officinalis and G. tetrahit. Treatment usually has to be timed to allow for staggered germination of the last species during April and May. Vegetables drilled and soft fruit and potatoes planted from late March to late April may encounter almost every species recorded during 1965-67. No single herbicide treatment can normally cope satisfactorily in these circumstances unless the crop is particularly vigorous. C. album and A. patula, as well as the 6 species mentioned above always require attention, but even the less aggressive species such as V. persica and C. bursa-pastoris can be major weeds in crops treated with lenacil or trifluralin respectively. The three perennial species are also troublesome in those crops. Red beet and French beans sown from mid-May to early June may be affected by small populations of the mainly spring germinating annuals, and by F. officinalis, S. arvensis, G. tetrahit and S. media but are more likely to encounter dense stands of C. album and A. patula than are crops planted earlier. Brassicas transplanted in early July mainly encounter these last two species together with S. media as major weeds. Autumn-planted crops such as flower-bulbs, transplanted spring cabbage and winter wheat usually carry stands of S. media and V. hederifolia, over the winter. Autumn germination of these species also creates problems in perennial fruit crops, while in overwintered crops of any type, F. officinalis may germinate on undisturbed soil from mid-January onwards. T. farfara is also a major problem from March onwards in overwintered and perennial crops.

These records show general agreement with the weed emergence data from Expts. I - III and demonstrate the many-faceted relationships between crops and weeds which may result from one basic weed flora. While such indirect comparisons are of value, there is a clear need for detailed evaluation of the emergence patterns and early growth rates of weeds in relation to particular crops and to successional sowing dates of one crop to clarify more precisely the weed control objectives in each situation.

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