The Weeds of Arable Land in relation to the Soils on which they grow.

BY

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DURING the last fifty years a considerable amount of work has been done on the various species of plants which are to be found associated in grass-land. The relations existing between the plants and the soil on which they grow have been well investigated, while the effects of different manures on the growth of the different species have been exhaustively tested at Rothamsted, the permanent experiments to this end extending over a period of fifty-four years.

While so much is known about grass-land vegetation, our knowledge of the relations existing between the weeds of arable crops and the soil on which they grow is more or less indefinite and vague. Many observers have recorded their impressions and observations,¹ but these have never been so tabulated and reduced as to give the information required in a systematic form.

This being the case, an attempt was made in the spring and summer of last year (1910) to devise some means of finding out how far the weeds of arable land are characteristically connected with particular soils and crops, and how far they are independent of either soil or crop.

As a beginning it was decided to limit the work chiefly to the soils overlying the well-defined geological series of rocks between Harpenden and Bedford, where within about twenty miles the Chalk, Gault, Lower Greensand, and Oxford Clay appear in well-marked succession. The bulk of the work ultimately centred in the Bedfordshire districts round Dunstable (Chalk), Harlington (Gault), Flitwick (Lower Greensand and Oxford Clay), and Woburn (Lower Greensand and Oxford Clay). Some investigations were also carried on near Hertford and Hitchin (Hertfordshire).

¹ 'On the Indications which are Practical Guides in Judging of the Fertility or Barrenness of the Soil.' By John Bravender. Journ. Roy. Agric. Soc., vol. v, 1845, pp. 567-78.

'On Agricultural Weeds.' By Professor Buckman. Journ. Roy. Agric. Soc., vol. xvi, 1855, pp. 359-81.

The working plan adopted was that of visiting as many farms as possible during the season (extending from May to August), and detailing the nature of the soil, the crop grown, and every weed found in each individual field. So far as was practicable the relative prevalence of the weeds was noted in each case, falling under five headings:—

- (1) Dominant.
- (2) Sub-dominant.
- (3) Very generally distributed.
- (4) Occasional.
- (5) Scarce or rare.

Much information was frequently obtained from the landowners or farmers as to the soil, rotation of crops, manuring, and troublesome weeds.

The data obtained in the field have been tabulated and analysed. It must be fully realized at the outset that what is set forth in this paper is essentially preliminary and to a large extent tentative in nature. Of necessity the year's work was confined to a very limited area, and before any definite conclusions as to the relations between the weed, soil, and crop can be arrived at, the work will need to be extended to embrace more numerous geological formations, and also to include the same formations in different parts of the country, in order that true comparisons can be drawn. It must be borne in mind that this paper simply sets forth the results of a careful study of a limited and localized area in one particular season.

During the season's survey about 150 fields were visited, yielding 107 species of weeds, representing 74 genera. Of these, 30 species, representing 28 genera, were each seen once only. In noting the weeds those plants only growing actually among the crops were taken into consideration, those occurring on the banks and hedgerows being ignored.

The classification of the soil was necessarily somewhat haphazard, as no mechanical analyses were undertaken during this preliminary survey, an arbitrary opinion on the nature of the soil in each case being formed on the field, and frequently modified or corroborated by the verdict of the farmer. In the absence of mechanical analyses it is very difficult to distinguish between a true clay and a clayey or heavy loam, a sand and a very light loam, &c., but experience enables one to gauge the texture of the soil sufficiently for the practical purpose of the investigation.

The more important species of weeds, with their habitats and relative dominance, were as follows:—

Ranunculaceae. *Ranunculus acris*. Most frequent on chalk and light loam; no record for gravel. Never dominant, and rarely found on very sandy soil.

Ranunculus arvensis. Chiefly found on clay land, but it occurred on

all other types of soil except sand. One record of dominance, on heavy loam.

Papaveraceae. *Papaver sp.* Usually associated with light sandy soils, where they were occasionally dominant. Sometimes found on chalk.

Fumariaceae. *Fumaria officinalis.* Occurs chiefly on chalk, where it is often dominant. Frequently found on sand (with one record of dominance); absent from clay lands.

Cruciferae. *Brassica alba.* Characteristic on chalk, where it is very often dominant; frequently occurs on sandy soils, but is *very* rare on heavy land.

Brassica Sinapis. Found on all types of soil, but most frequently on chalk and clay, where it is often dominant. Where it occurs on light soils it is usually scarce, though instances of dominance are recorded.

Capsella Bursa-pastoris. Occurs on all types of soil, but probably more frequent on light and sandy land. Rarely dominant.

Violaceae. *Viola tricolor.* Practically confined to light and sandy soils and chalk. Very rare on clay. Never dominant.

Caryophyllaceae. *Cerastium vulgatum.* Apparently distributed on all types of soil, but never very prevalent.

Spergula arvensis. Confined to sand and very light sandy soil. Frequently dominant.

Stellaria media. Chiefly found on sandy and light soils. Recorded from clay, chalk, and black land. When dominant it was usually on light and sandy soils.

Geraniaceae. *Geranium sp.* (It was difficult to absolutely fix the species in some cases.)

G. pusillum and *G. molle.* Only occurred on chalk and sand. Rarely dominant.

G. dissectum. Found on light loam.

This genus is practically confined to temporary leys of clover or 'seeds'.

Rubiaceae. *Sherardia arvensis.* Practically confined to chalk.

Galium Aparine. Of general occurrence, but possibly more frequent on light lands than on heavy soils. It rarely occurs in any quantity, but is usually occasional or scarce.

Compositae. *Anthemis arvensis* and *A. Cotula.* (Species were not clearly separated in the field.) Recorded from both light and heavy soils, but infrequent in occurrence in this area.

Chrysanthemum segetum. Only found on sand; very local, but characteristic.

Gnaphalium uliginosum. Usually associated with light sandy soils; never seen on chalk, and only once on clay. It seldom occurred in any quantity. (There is just a possibility that this represents a mistaken diagnosis of a certain small form of *Filago gallica*, which much resembles

Gnaphalium uliginosum. The habitats hardly correspond to those usually associated with the latter species.)

Matricaria Chamomilla. Confined to light sandy soils, with one solitary notice on clay. No record from chalk. Occasionally dominant on sand.

Matricaria inodora. Most frequently occurred on sandy soils, but was also found on clay. Seldom recorded from chalk. Dominant at times both on clay and sand.

Senecio vulgaris. Universally distributed, and of very frequent occurrence. Rarely dominant, and then on heavy soil.

Sonchus arvensis. Universal in distribution, both as to soil and dominance.

Thistles (usually *Carduus arvensis*). Universally distributed as to soil. When dominant it was usually on the lighter types of soil, not on clay.

Tussilago Farfara. 'Coltsfoot.' Universal in distribution, found on all types of soil. Frequently in association with *Equisetum arvense*. Rarely dominant.

Convolvulaceae. *Convolvulus arvensis*. Universally distributed, both as regards soil and dominance.

Scrophulariaceae. *Bartsia Odontites*. Recorded from heavy and light soils. Characteristic of heavy soils—clay; scarce on light lands.

Veronica agrestis. Of universal distribution, both as to soil and dominance.

Veronica hederæfolia. Recorded from all soils except gravel, though rarely seen on chalk. Dominant on all types of soil.

Labiatae. *Mentha arvensis*. Recorded from all soils but chalk. Frequently dominant on clay; usually occasional or scarce on light land.

Chenopodiaceae. *Chenopodium album*. Characteristic of light sandy soils, though frequently found on clay. No record on chalk, and very scarce on gravel. Rarely dominant, and then on sandy soil.

Polygonaceae. *Polygonum aviculare*. Very frequently found on sandy soils, and also occurred on clay. Very rare on chalk. Equally dominant on sand and clay.

Polygonum Convolvulus. Most usual on sandy soils, but frequently found on clay. Absent from chalk and gravel. Only dominant on sandy soil.

Polygonum Persicaria. Found on all soils except chalk. Only dominant on boggy land.

Rumex Acetosella. Characteristic of acid sandy soils.

Rumex crispus. Universally distributed. Probably more characteristic of clay and chalk than of light sandy soil. Dominant on clay, chalk, and gravel.

Gramineae. *Agrostis stolonifera*. Frequently dominant when found on gravel and chalk. Only occasional on clay and sand.

Alopecurus agrestis. Distributed over different types of soil, but probably more typical of heavy clay; scarce on chalk. May be dominant on either light or heavy soils.

Poa annua. Distributed over all types of soil except chalk. Only dominant on heavy clay.

Poa trivialis. Chiefly found on clay and chalk, but occasionally on rather sandy soil. Dominant both on chalk and sandy loam.

Triticum repens. Chiefly found on the lighter types of soil, though recorded from clay. Sometimes dominant on sand, once on chalk.

Equisetaceae. *Equisetum arvense*. Universally distributed and frequently associated with Coltsfoot. Occasionally dominant.

An examination of the tabulated and classified lists of results reveals the fact that while some weeds are universal in distribution, occurring on all types of soil indiscriminately, other plants are definitely symptomatic, only occurring in certain habitats, being absent from all others. (N.B.—While a weed may be said to be absent from any particular soil, still it is possible for it to occur in that very habitat as a stray, though very rare or occasional.)

A. Clay and Heavy Loam.

These soils originate from different geological formations.

- (1) Clay with flints (e.g. Hitchin).
- (2) Gault (e.g. Harlington, Tingrith).
- (3) Oxford Clay (e.g. Flitwick, Houghton Conquest, Woburn Sands, and Ridgmount).

Of these, very little data was obtained with regard to the clay with flints, and most of the results apply to the latter two.

The weeds on the heavy lands were relatively few as regards the number of species, especially in comparison with those on light and sandy soils, though the quantity of weed was equally abundant. It was found that with the solitary exception of *Mentha arvensis*, all the common clay weeds occurred on soils derived from both the Gault and Oxford Clay. *Mentha arvensis* was only found on the Gault and is very local, but it is quite possible that further search might discover it on the Oxford Clay as well.

The weeds most characteristic of clay soils were:—

Bartsia Odontites	Poa trivialis
Brassica Sinapis	Polygonum aviculare
Chenopodium album	„ Convolvulus
Matricaria inodora	Ranunculus arvensis
Mentha arvensis	Senebiera Cononopus
Plantago major	Veronica hederaefolia

Of these *Bartsia Odontites* and *Mentha arvensis* may be regarded as practically confined to clay, while *Polygonum Convolvulus* finds its home on clay or sandy soils only.

B. Chalk.

This includes both the chalk proper and the heavy chalk marl underlying it. The flora on these soils is somewhat sharply marked out, in that several plants which are otherwise universal in distribution are totally absent, because they are calcifuges.

Bromus sp.	}	are symptomatic of chalk.
Geranium pusillum		
Scabiosa arvensis		
Sherardia arvensis		
Silene Cucubalus		

Brassica alba	}	while very characteristic of chalk are also frequently found on sandy soils.
Fumaria officinalis		
Geranium molle		

Agrostis stolonifera	}	are of very frequent occurrence.
Alchemilla arvensis		
Brassica Sinapis		
Lychnis vespertina		
Poa trivialis		
Viola tricolor		

C. Light and Sandy Loam, including Sand.

These soils are of very mixed origin, as all the light lands on the different geological formations (excluding chalk) fall under this heading. Thus the loams may either be derived from—

- (1) Alluvium,
- (2) Lower Greensand ;

or they may be loams originating from drift overlying—

- (1) Gault,
- (2) Oxford Clay ;

while the sands proper are either—

- (1) Alluvial sands, or
- (2) Lower Greensand.

However, it is evident that the derivation of the soil has little or no effect upon the distribution of the weeds, the texture being the determining feature.

Chrysanthemum segetum	}	are confined to sand and are very sympto- matic, being probably associated with acid soil conditions.
Rumex Acetosella		
Spergula arvensis		

Thlaspi arvense, though found in but one locality, was also on sand only.

Geranium dissectum	} are characteristic of light and sandy loams.
Gnaphalium uliginosum	
Lamium purpureum	
Matricaria Chamomilla	
Papaver sp.	
Rumex obtusifolius	

Alchemilla arvensis	} are all chiefly associated with these light soils, though occurring on other types as well.
Brassica alba	
Chenopodium album	
Fumaria officinalis	
Geranium molle	
„ pusillum	
Lamium amplexicaule	
Lychnis vespertina	
Matricaria inodora	
Polygonum aviculare	
„ Convolvulus	
Triticum repens	
Veronica hederaefolia	
Viola tricolor	

Besides the weeds detailed in the foregoing lists, there are several which are quite universal in distribution, occurring on all types of soil, and which may be dominant on any soil. Such plants are the following—those which are of universal occurrence, with the exception of chalk, being given separately :—

Weeds of universal occurrence.

Anthemis sp.	Ranunculus acris
Capsella Bursa-pastoris	Rumex crispus
Cerastium vulgatum	Senecio vulgaris
Convolvulus arvensis	Sonchus arvensis
Equisetum arvense	Stellaria media
Galium Aparine	Taraxacum Dens-leonis
Myosotis arvensis	Thistles
Phleum pratense	Tussilago Farfara
Plantago lanceolata	Veronica agrestis
Scandix Pecten—not on sand.	

Weeds universally distributed, but absent or very rare on chalk.
(*Calcifuges.*)

Alopecurus agrestis	Polygonum Persicaria
Anagallis arvensis	Veronica arvensis
Euphorbia sp.	„ hederæfolia
Poa annua	

Besides the plants noted in the foregoing lists, a number of species occurred which were observed very seldom or once only during the season. The habitats are appended for purposes of reference.

Ranunculaceae	Ranunculus bulbosus	light and sandy loam
Cruciferae	Arabis Thaliana	„ „
„	Barbarea vulgaris	bog peat
„	Brassica campestris	sandy loam
„	„ oleracea	sandy loam and chalk
„	Raphanus Raphanistrum	sandy soil
„	Sisymbrium officinale	sand
Resedaceae	Reseda lutea	chalky loam
Caryophyllaceae	Arenaria serpyllifolia	chalk
„	Lychnis diurna	sand
Geraniaceae	Geranium columbinum	chalk marl
Leguminosae	Vicia hirsuta	sandy loam
„	„ tetrasperma	„ „
Rosaceae	Potentilla anserina	light loam
Umbelliferae	Aethusa Cynapium	various
„	Carum Petroselinum	heavy clay
„	Conopodium denudatum	chalk
„	Daucus Carota	„
Valerianaceae	Valerianella olitoria	chalk
Compositae	Centaurea nigra	clay
„	„ Scabiosa	chalk
„	Filago Germanicum	sand
Campanulaceae	Campanula hybrida	sand and clay
Boraginaceae	Borago officinalis	sand
Plantaginaceae	Plantago media	various
Scrophulariaceae	Linaria spuria	heavy clay
„	„ vulgaris	chalk and clay
„	Veronica Buxbaumii	light loam
„	„ serpyllifolia	sandy loam
Labiatae	Glechoma hederacea	clay
„	Prunella vulgaris	„
Illecebraceae	Scleranthus annuus	sand

Polygonaceae	Rumex Acetosa	sand
Euphorbiaceae	Euphorbia exigua	various
"	" helioscopia	sand
"	" Peplus	various
Urticaceae	Urtica dioica	sand
Dioscoreaceae	Tamus communis	chalk
Liliaceae	Allium vineale	heavy clay
Gramineae	Bromus arvensis	chalk
"	" asper	"
"	Holcus lanatus	sand and clay
"	Hordeum pratense	heavy clay
"	Lolium perenne	various
"	Phleum pratense	"
"	Poa pratensis	gravelly loam

Points of Interest.

1. While the nature of the soil plays such an important part in determining the local weed flora, the character of the crop, generally speaking, is a matter of indifference. The one exception to this rule is in the case of seed crops—clover, lucerne, sainfoin, trefoil. Many weeds, though they are to be found with every other crop, are entirely absent or very rare with seeds. This may be due to the difference in habit, as the Leguminous plants cover the ground so closely with such a dense mass of herbage that probably many weeds are choked out. One or two species, especially *Geranium* sp., *Cerastium vulgatum*, and *Sherardia arvensis*, are almost entirely confined to such crops, and it is possible that these weeds are not indigenous, but are introduced with the seeds of the crop.

A very few species are practically *confined to cereal crops* :—

Anthemis Cotula	Centaurea nigra
Brassica alba	Poa annua
" Sinapis	

Weeds absent or very rare in seed crops.

Agrostis stolonifera	Poa annua
Anagallis arvensis	Polygonum aviculare
Chenopodium album	" Convolvulus
Equisetum arvense	" Persicaria
Galium Aparine	Ranunculus arvensis
Gnaphalium uliginosum	Scandix Pecten
Mentha arvensis	Spergula arvensis
Plantago major	Stellaria media

Triticum repens
Tussilago Farfara
Veronica agrestis

Veronica arvensis
 „ *hederaefolia*

It should be noted that while *Poa annua*, *Plantago major*, and *Ranunculus arvensis* are absent from seed crops, other species of the same genera, e. g. *Poa trivialis*, *Plantago lanceolata*, and *Ranunculus acris*, are very frequent in such surroundings. While the variety of crop does not greatly influence the weed flora, still the cultivation frequently affects the prevalence of certain weeds the following year.

2. Care was taken to discover the various species of plants designated as 'Twitch' in the different localities. Any grass which runs along the surface of the soil or covers it to any great extent is apparently so called, the following species being included under this heading :—

Agrostis stolonifera
Alopecurus agrestis
Lolium perenne

Phleum pratense (var. *stolonifera*)
Poa annua
Triticum repens

3. Special investigations were made to determine whether Coltsfoot and *Equisetum*, which so often occur in company, are in any way characteristic of some particular quality of soil. Samples of the soil were tested with litmus for acidity and hydrochloric acid for alkalinity, with the result that both species were found to occur indiscriminately, and so could not be regarded as indicative or symptomatic.

Spergula arvensis, 'spurry,' on the other hand, is very symptomatic of acid soils, and it disappears entirely where lime is applied, reducing the acidity. Lime also kills out Mayweed in many cases.

4. 'Mayweed' (*Matricaria* sp. and *Anthemis* sp.) seems to be very impatient of competition. If the crop is in any way heavy little or no Mayweed is to be found among it, though it occurs in enormous quantities round the edge of the fields, along lines of drainage, and wherever there may be a clearing in the crop.

Fumaria officinalis does not generally occur in any great abundance, but occasionally it is so prevalent on chalk that it is necessary to hand cultivate to get rid of it in order to save the crop. This is notably the case in the Maiden's Bower, an old Roman encampment near Dunstable.

Allium vineale was only met with in one locality on the very heaviest of clay land. This weed reproduces itself by offsets, bulbils, and seeds, and its vitality is so great that no known method of cultivation seems competent to eradicate it.

SUMMARY.

1. A definite association exists between the species of weeds of arable lands and the soil on which they grow. The determining factor is the actual texture of the soil, and not so much the geological formation from which it is derived, except with soils overlying chalk.

2. The crop has very little influence on the weeds occurring except in the case of seed crops, which probably smother out a number of species which would normally occur.

3. Certain weeds are definitely symptomatic of particular types of soil, though the majority of species are not so strictly circumscribed in distribution. Some species, also, are to be found indiscriminately on any soil.

In conclusion I have to express my great obligation to Mr. Spencer Pickering, F.R.S., who obtained for me numerous introductions, without which the work would have been impossible. Also I desire to thank all those who so greatly facilitated the work by permitting me to visit them and by giving me much information and practical help.

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