Wednesday November 3rd
Afternoon

WEED SEEDS

Chairman: MR. TOM DUKE

WEED DISPERSAL AND PERSISTENCE

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The two aspects of weed occurrence which I propose to consider, namely, their dispersal and their persistence, cannot logically be separated from one another since the dispersal of seeds in space is so intimately associated with their persistence in time, inasmuch as it is the spatial distribution of viable propagules that is alone significant. Certain facets of my subject were adumbrated by Mr. Horne in his excellent account of the significance of weed seeds at the 1953 Conference, but in order to give a balanced picture it will be necessary for me to recall some of the points to which he alluded.

The importance must not be ignored of the effect, upon dispersal of species, of whether a single individual arising from seed can effectively reproduce its kind. In other words can such be an effective source of infection? Clearly, this condition would not obtain if the species were self-sterile or almost entirely self-incompatible. On the other hand an apomictic species such as Taraxacum officinale or a wholly self-fertile species such as Capsella bursa-pastoris can effectively increase though but a single individual be present. Furthermore, these two species are to a considerable degree independent of the weather conditions obtaining at the time of flowering since the Dandelion sets seed without pollination whilst pollination and even fertilisation take place in the Shepherds Purse before the flowers open. The Chickweed, Stellaria media is another abundant weed which is markedly self-fertile and in which pollination occurs even when climatic conditions are unfavourable. Aphanes arvensis is according to Gustafsson a pseudogamous polyploid, Hypericum perforatum is apomictic and so too are the grasses Agrostis stolonifera and Poa annua.

In this connection it should also be noted that the range of potential spread is greater for many common weeds by reason of their not being dependent upon a particular photoperiodism for flower production.

From the point of view we have just been considering, a most instructive contrast is afforded by the two species of introduced Speedwells namely Veronica persica and Veronica filiformis. The former sets seed freely whereas the latter is self-incompatible and in consequence commonly produces seed but sparsely. Veronica persica spread very rapidly by virtue of seed dispersal all over Great Britain whereas the self-incompatible Veronica filiformis spreads but slowly from locality to locality although by virtue of its vegetative propagation it extends its area rapidly in a locality to which it has gained access. These congeners illustrate the importance of the dispersal mechanism as influencing the time factor in the spread of weeds.

One important aspect of weed seed dispersal, because it is a means by which species not known in an area become introduced, is in the actual seeds sown. Modern screening methods have greatly reduced this source of contamination which so far as cereals are concerned is now almost negligible. In grass and Clover seed the elimination of such impurities though it is much more successful than formerly, is by no means complete, and from recent data as to the proportion of weed seeds present in average samples, it appears probable that some 40,000

weed seeds per acre are sown inadvertently in this way each year. It might appear as if it were a comparatively simple, even be it expensive, matter to devise mechanical means of separation to a much higher rate of purity. Such a view, however, does less than justice to our conscientious seed merchants. For just as the screening of seeds becomes more and more efficient, so, too, is the unconscious selection of the strains within a weed species with respect to seed size and other physical characters upon which our differential screening depends. May I remind you here of the experiences recorded by Prof. Vavilov regarding the attempts to eliminate tares from the crops of Ervum lens in Russia. By the installation of screening devices a considerable reduction was achieved which, however, was but temporary, for it soon became manifest that a strain of tare had been selected out which had a seed size almost identical with that of the Lentil, and the population of this in the absence of competition with the smaller or larger seeded strains built up to the former population level of the species as a whole. Hand picking, on the basis of colour and markings, was then resorted to with again but a temporary amelioration of the pest. But the final outcome was an artificially selected strain with seeds identical in form and appearance to those of the crop plant with which it was associated.

It might be thought that modern improvements in screening methods would more often have eliminated impurities, but it is significant that even in America, where the mechanical removal of weed seeds has, perhaps, attained the greatest efficiency, more than half the seed samples of the major crop plants in the State of New York still contain sufficient weed seeds that over one hundred per acre may be sown (c.f. B. E. Clark & H. BeLittle, N.Y. State Bull. No. 760.1954), and this applies even to certified seed, though the proportion of adventitious seed naturally varies greatly with the crop species concerned. In the State of California out of nearly 4,000 samples of Seed examined in 1953 6% contained seeds of noxious weeds.

An example of a species probably introduced by being sown with the crop seed is the near-eastern Wild Oat, Avena ludoviciana. The investigations of Miss Thurston on Wild Oats have revealed that this winter-germinating species, possibly introduced about 1926, has now become a frequent weed ranging from Somerset, Worcester and Northamptonshire, south-eastwards to Hampshire and Kent, whilst sporadically it occurs as far north as Newcastle and westwards to Exeter. Owing to the similarity of their propagules, the most efficient screening methods are of little avail in separating the Wild Oat from its cultivated congener, whilst the prolonged viability of the 'seeds' of the Wild Oat increases the difficulty of eradication by cultural methods.

The former prevalence of the Darnel (Lolium temulentum) and the Red Chamomile (Adonis annua) was probably due to their repeated introduction with imported seeds, and their diminution and present rarity, to the efficacy of modern screening technique, but not many years ago I saw a cornfield in Hertfordshire which betrayed the near-eastern provenance of the seed sown by the prevalence of Silene dichotoma.

During the early years of the last World War I had the opportunity of studying the advent of weed species to the bombed sites of London, which afforded an unique opportunity of assessing the relative efficacy of the diverse modes of dispersal. (This I estimated on the basis of the frequency of occurrence of species belonging to the various dispersal categories (Proc. Roy. Inst. 1942.))

One important conclusion that these results appeared to establish was the great significance of the upward convection currents for the dispersal of wind-borne propagules. The role played by what are commonly termed wind-dispersal mechanisms would seem to be mainly in facilitating this upward carriage and in delaying the rate of fall when the direction of movement is reversed. The slower

the latter the greater the statistical probability that the fruit or seed will be caught in a transverse wind current that will vastly increase the potential range of infection.

A study of the spread of introduced weeds shows that their dispersal tends to exhibit two phases that are commonly contemporaneous. There is what may be termed the 'Primary Spread', which is more or less continuous in character around the original infection centre. There is also the appearance of new infection centres at a distance from the original area which we may term the 'Secondary Spread', and it is probably in relation to this Secondary Spread that the 'dispersal mechanisms' have their most significant effect and against which the normal methods of farm hygiene are of little avail.

Of a total of nearly 140 species of flowering plants, the first establishment of which I was able to observe on these bombed sites, those whose propagules are distributed mainly by the agency of wind represented the highest percentage of the total (ca.30 per cent.), and moreover, these were usually present on the greatest proportion of the bombed areas, (Groundsel 88 per cent., Rosebay Willowherb 88 per cent., Oxford Ragwort 56 per cent., Sow Thistle 44 per cent.). Next in importance were the species the seeds of which are mainly dispersed by birds. These accounted for nearly a quarter of the total, whilst those species which are largely dispersed by Man represented about 15 per cent. As, however, a large proportion of the bombed areas were only accessible with difficulty, it is reasonable to assume that the figure for human carriage is too low, and it may well be that in the absence of artificial barriers dispersal by Man might well account for nearly 20 per cent.

Wind dispersal is usually, though not always, the most rapid type of dispersal. The rate of spread by this agency is well shown by consideration of the records of occurrence of species that have spread widely in recent years such as the Oxford Ragwort (Senecio squalidus), the Sticky Groundsel (Senecio viscosus) and the Canadian Fleabane (Erigeron canadense) all of which, like the Rosebay Willowherb (Chamaenerion angustifolium), spread rapidly as soon as the requisite infection pressure was established. The much slower rate of spread of Gallant Soldiers (Galinsoga parviflora) which has a relatively inefficient pappus emphasises the importance of the dispersal mechanism in this connection.

We have already noted the importance of dispersal by Birds which is probably most frequently exercised through internal carriage and deposition with the excreta. It will be recalled that W. F. Collinge raised numerous seedlings from the droppings of various common birds which had been sown on sterilised soil. Similar observations of others have served to confirm that this is a very significant factor in dispersal. The more so that an appreciable distance may separate the place of feeding from the location of evacuation. The time that elapses between the swallowing of the seeds or fruits and the evacuation of the faeces is naturally subject to appreciable variations, but usually ranges from as little as thirty minutes to three hours or more.

Many common weed seeds, such as Shepherds Purse (Capsella spp.), Fat Hen (Chenopodium album), Ribwort (Plantago lanceolata), Groundsel (Senecio vulgaris), Spurry (Spergula arvensis) and Chickweed (Stellaria media), have been obtained in this way from the droppings of sparrows, which must, from the large size of the sparrow population, constitute a very effective means of local dispersal from field to field and farm to farm.

Of more significance for longer distance dispersal is the agency of the Pigeon, from the droppings of which viable seeds have been obtained of various serious weeds such as Charlock (Sinapis arvensis), Greater Plantain (Plantago major), Poppies (Papaver spp.), Pennycress (Thlaspi arvense) and Irongrass (Polygonium aviculare).

Having regard to the considerable distances that may be traversed by Pigeons in the space of three hours, and their greatly augmented numbers in recent years, that has caused such concern to agriculturists from other aspects, it may well be that pigeon carriage is one of the most important means of longer distance infection through fruits and seeds which do not possess a highly efficient structure for wind dispersal.

Distribution by stock in their excreta is important not only because the volume of such is considerable, but the movement between feeding and excretion often appreciable. Burton and Andrews found that most seeds were evacuated by cattle on the second or third days after being eaten, but some, not till the 10th day. Also by reason of the long distances that these excreta, in the form of manure, may be transported to be incorporated in the soil of another farm, this mode of infection may be particularly significant. Very large numbers of fruits and seeds are known to be capable of surviving in the excreta of cattle, and indeed, the number of different species which can retain their viability and even exhibit more rapid germination after passage through the digestive tract of the Cow is probably considerably in excess of those actually recorded. We may note that the list of these includes Plantains, Docks, Nettles, Buttercups, Chickweed, Shepherds Purse, Atriplex, Fat Hen, Mayweed, Cleavers, Rushes and Wild Oats, to mention but a few.

It is, of course, true that the high temperatures that can be attained in the interior of a manure heap often destroy the viability of many of the fruits and seeds contained therein, but since such lethal temperatures are not reached towards the periphery of the heap, a very appreciable viable residue may remain.

It is very probable that, apart from local spread, the Thanet Cress (Cardaria draba) has owed its transport for greater distances to carriage in manure. This very aggressive weed is known to have come to the Isle of Thanet as its first recorded appearance in Britain, through accidental introduction with the hay-stuffed mattresses on which our fever-stricken marines were brought home from the ill-fated Walcheren expedition about 150 years ago. The early development of adventitious shoots from even small fragments of the underground parts results in rapid local spread through normal cultivation. The seeds are, however, large with no specialised mode of dispersal, so that long distance carriage is perhaps largely due to carriage in manure. The appearance of this species on the soil dump a year or two after the Elstree tunnel was widened illustrates this kind of dispersal, since no doubt the trucks used for conveying the clay excavated from the tunnel had previously been employed to carry manure. The Thanet Cress appeared here on a site at that period very many miles from its nearest known locality.

A certain number of common weeds have seeds that become sticky when moistened, such for example, as those of the Shepherd Purse (Capsella), Thale's Cress (Arabigdopsis thaliana), the Ribwort and Greater Plantain (Plantago lanceolata and P. major), and the Rush (Juncus tenuis.) All these seeds can adhere to implements of cultivation and where such are not cleaned after use they can serve to convey the weeds to the field when next used. But such seeds also adhere to the feet of stock and the boots of man. That the last named is not a negligible factor is illustrated by the American Rush, Juncus tenuis. Soon after this began to spread in Britain, some 30 years ago, I found a colony of it growing on the roadside at Portmadoc. A few years later I noted it growing at intervals all along the footpaths leading to Beddgelerts grave, obviously carried there on the feet of tourists who visit this spot in considerable numbers.

External carriage of fruits and seeds by stock is perhaps far less important than external carriage by man, although the dissemination of the fruits of Cleavers (Galium aparine), Bugloss (Echium vulgare), Field Buttercup (Ranunculus arvensis) and Wild Barley (Hordeum murinum) in the fleece of sheep is not significant. Nevertheless, because of man's greater and more frequent mobility, he is probably the most active though usually unconscious agent of external transport. Because little thought about, the great importance of ourselves as dispersal agents is usually overlooked. The two most significant ways in which man transports propagules are on his clothes and in soil on his footwear. The rapid spread of the Oregon Pineapple weed (Matricaria matricarioides) was almost certainly due to transport in mud both on boots and motor tyres.

Some years ago I carried out a number of experiments that shed light on the frequency with which propagules were carried in the mud adhering to human footwear. The method used was to obtain samples of the sweepings from churches at intervals throughout the summer months until just before Harvest Festival. The churches chosen were ones that had an appreciable length of paved approach to the church porch so that propagules shed almost immediately after being picked up were eliminated. Most of the common weeds appeared on the sterilised soil on which the church sweepings were sown, and grasses showed the highest frequency.

The N. American weed Claytonia perfoliata was a rare introduction half a century ago. Then it got into a well known nursery and became widely dispersed in gardens thereafter, from the distribution of the seeds with nursery stock. So, too, many years ago it became abundant in the Botanical Garden at Cambridge and subsequently appeared in quantity by the Breckland tracks, perhaps brought on the feet of the botanical students that frequent that area.

To assess the importance of carriage on human clothing I collected samples from the trouser-cuffs of myself and my friends after walks in the country. It will perhaps suffice to state that the harvest of one such produced well over 300 seedlings. Transport by human movement is in dry weather mainly on clothing and in trouser cuffs. When the soil is moist, however, transport in mud becomes far more important. Calculations based upon the amount of mud clinging to boots and the normal number of viable seeds present in a unit volume of agriclutural soil would appear to suggest that on a conservative estimate we probably carry at least six seeds in the mud on our footwear and during the autumn the number may be of the order of two hundred or more. It is obvious therefore that this is a by no means negligible source of infection from field to field and even from farm to farm.

The evidence furnished in my 'Reproductive Capacity of Plants' demonstrated a marked degree of correlation between reproductive capacity and frequency. As a result of those studies I concluded that for 'ecologically comparable species the magnitude of the reproductive capacity is associated with the frequency and abundance of which it is probably one of the determining features'. It might however, at first sight, appear that some of the commonest weeds were a striking exception to this generalisation since the seed output of such abundant agricultural weeds as Shepherds Purse, Groundsel and Chickweed, for example, are not outstandingly large.

In comparison with other annual weeds species, however, we have to take into consideration that all three species we have just mentioned are short-lived annuals that normally compass more than one generation in a year. With a view to assessing the importance of this aspect a number of weed seedlings were marked as soon as they germinated and the period that elapsed before ripe seed was produced was noted as well as the time taken to complete seed ripening.

It is necessary to stress the importance of meteorological conditions in affecting the span of these biological events. Nevertheless, it would appear that for Capsella bursa pastoris agg. Stellaria media and Senecio vulgaris a period of from five to six weeks normally suffices between germination of the seed and the shedding of the first ripe seeds from the new plant. One plant of Shepherds Purse that was kept under observation was estimated to have shed some 3,630 seeds within nine weeks from germination on which basis the potential population at the end of the summer would be the product of three generations and if most individuals survived might exceed half a billion. Similar estimates with respect to Chickweed plants of which more generations usually occur indicate that potentially one of these could by the end of the year produce an astronomical population measured in million billions of individuals. We know that in fact the majority of these potential individuals perish either as seed or very young seedlings, but the point of interest is that far from being an exception to our generalisation, respecting seed output and frequency, these common weeds emphasise its validity.

Estimates of the average seed output of common weeds based upon random samplings indicate about 1,300 fruits per plant for Groundsel (Senecio vulgaris) between 2,000 and 3,000 for Shepherds Purse (Capsella) according to the species concerned and about 2,000 for the Chickweed (Stellaria media), outputs that are small compared with the 17,000 for the common Poppy (Papaver rhoeas) if we do not take into account the number of generations per annum which is normally but one for the Poppy but three for the Shepherds Purse, and may be four or even five for the Chickweed and Groundsel. Moreover their photoperiodic indifference and capacity to ripen seeds under almost any climatic conditions implies that the dispersal of these species has none of the seasonal limitations imposed upon many other plants. Their seeds thus constitute a bait for birds all the more effective because they are often produced when other food is scarce. The toll taken is fantastically large, were it not so the astronomical potentialities for reproduction would have doubtless produced a population appreciably larger than actually obtains.

But it is obvious that these vast outputs and the much smaller though still large annual seed production of many weeds that only produce one generation in a year would be of far less significance if their viability were brief. In actual fact most weed seeds can remain viable for very long periods, especially when the imposed dormancy is due to burial in the soil It will sufficiently illustrate this aspect to recall that Chickweed seeds (Stellaria media) have germinated after 30 years burial, Black Nightshade (Solanum nigrum) and Fat Hen (Chenopodium album) after 40 years, and I obtained conclusive evidence of the seeds of the Blue Pimpernel (Anagallis Foemina) germinating after more than a century.

Furthermore it has been shown that although viable seeds are most abundant in the upper layers of the soil and therefore liable to be brought sufficiently near the surface by ploughing to germinate, nevertheless a by no means negligible number of seeds occur below the normal depth of cultivation and thus constitute a reservoir of infection.

The old adage, one year's seeding is seven years' weeding is thus a masterly understatement, and the high potentiality for seed production of a single indovo-individual Poppy or Shepherds Purse can by reason of induced dormancy ensure persistence throughout the vicissitudes of any rotation and provide the means of infection for other areas over many years.

WEED SEED DISPERSAL BY MACHINERY

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Introduction

All field operations by machinery result in the movement of some weed seeds, but only those operations which result in either bringing seeds already in the soil into an environment which will encourage their growth or which disperse viable seed from weeds already present, are of importance to the farmer.

It is the purpose of this paper to examine those operations and machines which tend to increase weed populations.

Tillage.

Whilst tillage operations of all types are designed to control weeds, it should be remembered that cultivations to a greater depth than normal are likely to bring dormant weed seeds into an environment which will encourage their establishment. Examples of this are the infestations of Charlock (Sinapsis arvensis), even on land where this weed has been controlled for some years by spraying, and of Wild Oats (Avena fatua and A. Ludoviciana) (11), which occasionally follow deep ploughing. The deeper cultivations having brought up seeds which had been carried below normal ploughing depth.

Farm Yard Manure Handling

The introduction of farm yard manure spreaders has led some farmers to employ the technique of loading their spreaders directly from the cow sheds and then spreading the fresh dung before it has had time to heat up and destroy the weed seeds which are present. Such usage of manure spreaders can lead to infestations of weeds.

Haymaking

During haymaking, particularly in the wetter areas where the hay crop is allowed to mature more fully, every operation from mowing, swath turning and windrowing to sweeping, stacking or baling is likely to spread any ripened seeds which may be present. The dispersal of these seeds is of importance where they are from acknowledged weeds or from grasses such as Brome grass (Bromus sp.) and Yorkshire Fog (Holcus sp.), which are unproductive or unpalatable and should be classed as weeds in good grassland.

It is unlikely that any re-design of the mowing machine would reduce the shedding of ripe seeds at this stage of haymaking.

The operations of swath turning and windrowing are of greater importance, as during the curing of the hay more seeds have ripened and will be shed. Those machines which handle the crop gently should be chosen for this work. The types of swath turner and side delivery rake based on a series of inclined, toothed wheels driven by their contact with the ground have much to commend them as they have a very light touch on the crop.

Hay sweeps which can be lifted clear of the ground when they have been loaded, reduce seed shedding on the run back to the rick. At the rick there is always a concentration of seeds around the foot of the elevator. The use of push-off stackers, i.e. hay sweeps which are mounted on fore-end loaders and fitted with a hydraulic ram to push the load off the tines, largely eliminates seed shedding during transport and elevating up to the top of the rick.

The pick-up tines and feed augers of balers together with the rough treatment by the ram in its open bale chamber all give rise to further seed shedding.

In the opinion of the author, haymaking provides a field for much investigational work on seed shedding; he would suggest that counts of weed seeds shed at each stage of the process, including cocking and piking and a comparison of the seed shedding propensities of the roll-up and ram types of baler would be well worth while.

The Corn Harvest

The field operations required to harvest corn crops are by far the most important in the dispersal of weed seeds, since by July and August a great many more species of weeds have produced ripe seed which is ready to shed freely.

In comparing the combine harvester with the self-binder technique of harvesting, due regard must be paid to the differences in crop development required by them.

Harvesting with the binder is undertaken some 7 - 10 days before the crop would be ready for the combine harvester, and in this time, in some seasons, a number of weeds will have shed their seeds.

It must also be realised that while the weed population under the swath of straw left by the combine may appear to be heavy, it is concentrated into a much smaller area than the even spread of weeds resulting from the many field operations of the binder technique.

The Binder

The operation of a binder involves losses of seed at the cutter-bar, from the inner end of the platform canvass, at the head of the elevator canvasses and from the foot of the binding deck. Further losses of seed occur when the ejected sheaf strikes the ground, during stooking and again when the sheaves are pitched up to trailers. The beds of trailers and carts are collecting points for weed seeds, and badly fitting floors allow seed to fall to the ground all the way from the field to the stack.

The threshing machine offers good facilities for the separation and collection of weed seeds. The machine is set level all the time it is in work, which enables the straw-walkers and reciprocating sieves to do their work efficiently. The separating surfaces are also of a much greater area than in most present designs of combine. Where the chaff and cavings are blown into heaps, as in the American type machines, there is some danger of the lighter weed seeds being dispersed by the air blast or the wind. The use of sheets under the thresher are recommended as an easy way of collecting small seeds.

It is difficult to assess the quantity of weed seeds shed at each stage of the binder method of harvesting. If, however, it can be accepted that weed seeds are as likely to shed as the grain, then the following analysis of grain losses by MacKenzie may be taken as a guide.(10)

MacKenzie found the overall losses in wheat to be 3.5% when using the self-binder as compared with 1.1% with the combine harvester. Analysis of the losses with the binder is given in Table 1.

TABLE I

LOSS OF WHEAT IN HARVESTING WITH BINDER AND SEPARATOR

Grain lost	Lb. per acre
Behind binder knife	16.52
In stooking and around stooks	22.23
Below bundle carrier	17.61
On bundle rack	5.69
In separator	11.32
Total loss	73.37

Gross yield, 34.18 bushels per acre

Percentage loss, 3.58%

Blauser quotes field losses using the binder method as ¾ bushel per acre at the cutter-bar and 1 bushel per acre around the stooks, (1).

Kinsman confirms the loss of grain at each of the points already mentioned in the binder method and his comparison of harvesting methods gave losses with the combine of 2.6%, with the Header of 3.3% and with the Binder of 6.1% (7).

This evidence taken in conjunction with Wirt's finding that ripe weed seeds are removed by the combine at similar rates to other methods of harvesting, indicates that weed seed losses are likely to follow the same pattern as grain losses. (11).

It is customary to use collecting trays, beneath the bottom rollers and at the foot of the binding deck, when cutting small seeds with the self-binder, and the use of such trays can effect a saving of up to 50 lb. per acre. The use of such trays for the collection of weed seeds in a dirty crop is recommended. (8).

The Combine Harvester

The combine harvester has been given a bad name as a disperser of weed seeds. Horne regards it as "an almost perfect biological device for the dispersal of weed seeds". (5); on the other hand MacGregor finds that at the time of combining the bulk of the weed seeds are either too green to grow or so ripe that they have already shattered; he also reports no increase in weediness of land which has been combined for several years as compared with other methods of harvesting. (9).

It is of interest to note that a good deal of work was done in America on weed dispersal with combine harvesters in the period 1920 - 1940, by which time the problem was considered to be of comparatively little importance. (1,7,9,10,11). The investigations made during this period showed up the weak points of those combine designs which allowed weed seeds to be returned to the land, with the result that manufacturers quickly modified their machines to retain and bag these seeds.

The principle of cleaning the threshed grain by winnowing over reciprocating sieves, does, however, allow seeds with a lower density than the grain being harvested, to be blown out with the chaff; thus, as Horne reported to this Conference last year, the combine is responsible for the spread of thistle species, such as Spear Thistle (Cirsium vulgare). (5).

Cashmore writing in 1945 reported an average yield of weed seeds of 2.4 lb. per acre from 22 tests, although in 10 of the tests the yield was too small to measure. In each case the seed was recovered from the chaff passing over the back of the combine. The same tests showed that weed seeds of similar density to the grain were retained and delivered with the grain. (2).

The effectiveness of separation by sieving depends on the sieve oscillating with one principal dimension horizontal, this condition is not attainable in the combine, owing to variations in the slope of the land over which the machine is travelling. The seed on the sieves tends to run to the lower side and the capacity of the sieve is reduced. A number of manufacturers divide their sieves into sections by longitudinal strips to reduce this trouble, but the lower side of each section can still become clogged and allow seed to overtail; in the case of the cavings riddle the tailings fall to the ground with the chaff.

The difficulty of designing adequate cleaning mechanisms, which operate effectively in the difficult conditions met with in the combine, and their high cost, have led a number of workers to investigate the operation of simple combines which do not attempt any separations other than of the straw, all the grain, chaff, cavings and weed seeds being blown into enclosed trailers. The necessary separations are carried out at the farmstead where the cleaning machine is on level, stable foundations and all the bye-products, including weed seeds are under full control.

Most of the work on these simplified combines has been carried out in Europe. Herbthofer recommends the use of a small combine with a cutter bar of 1 to 1.5 metres width, (3¼ to 5 ft. approx.) and no winnowing, the grain and chaff being blown into a tanker trailer. (4). Hamblin working on a mounted combine for harvesting trial plots, used an endless belt type of threshing mechanism, which obviated the use of straw-walkers and enabled him to retain the chaff and weed seeds whilst obtaining some measure of grain separation. (3).

Where no separation of grain and chaff is made in the combine, the special trailers required and the great bulk of the material to be transported from field to farmstead militates against the general adoption of this method.

Apart from the losses of weed seeds from the combine whilst it is in work, the machine can carry seeds from field to field. Hurlbut reports finding as much as 613 lb. of material on ledges and in crevices within a combine after external cleaning had been carried out. (6). Analysis of where this material was found is given in Table II.

TABLE II

ANALYSIS OF MATERIAL RETAINED BY COMBINE

Cutter-bar and elevator	7.8%
Threshing unit	1.5%
Tailings auger and elevator	5.2%
Main auger	31.6%
Grain auger and bin, emptying auger	53.9%

The retention of so much material within the combine and the liability of distributing it whilst in transit, indicates that further attention should be given to cleaning up the design of those parts which retain most and ensuring that a minimum leakage of seeds from auger casings can take place.

Weed seeds are dispersed whenever they are present as contaminants in crop seeds sown on the farm. In this connection some of the new farming methods can give rise to fresh problems in this field. For instance, the use of selective herbicides can result in denser populations of resistant species. In some areas, the incidence of Cleavers (Galium Aparine) in Atle wheat makes the cleaning of the grain difficult as the seeds have similar shapes and densities.

Fortuitous Dispersal by Machines

All field machinery can be responsible for carrying weed seeds from place to place, if they are not thoroughly cleaned. Tractor and trailer wheels, seed drills, hay making machines, combines and threshers being typical examples.

In conclusion I would like to suggest that whilst machines may disperse weed seeds by reason of their design, their proper maintenance and adjustment and the technique of their usage in the field are also of great importance.

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INJURIOUS WEED SEEDS AND WEEDS

THE PRESENT POSITION CONCERNING THE LAW

J. A. MCMILLAN (National Agricultural Advisory Service)

I claim no flair for interpreting the law. Yet it would be difficult to introduce this talk without referring to certain details in the existing legislation. I propose to say something on the Acts and Regulations having a reference to injurious weed seeds, then on the law as it relates to injurious weeds. Later, we might briefly look at our present legislation against the more recent changes in practice on the farm and in the merchant's warehouse and take a cautious glance into the future.

The Seeds Act, 1920, with the amendments of the 1925 Act and of Section 12 of the Agriculture (Miscellaneous Provisions) Act, 1954, provide the foundation for the Regulations on injurious weed seeds. The Act is short, concise and can readily be understood. It lays down that a seller of seed or seed potatoes, on or before the sale or the delivery of the seed, must give the buyer particulars as to variety, purity and germination. These particulars must also be displayed on or near seed or seed potatoes exposed for sale. Tests to furnish the necessary particulars as to purity and germination must have been carried out either at an official seed testing station or a station licensed by the Minister, but in the case of garden seeds they may have been tested "in any other sufficient manner". The Act also lays down that it is not lawful to sell or expose for sale or knowingly to sow any seeds which contain more than a prescribed percentage of certain injurious weeds.

There are exceptions to the above provisions, e.g. when seeds are sold to a purchaser who intends to clean them before re-sale, or when a purchaser gives a written undertaking that the seeds will be tested before re-sale or when seeds are sold or exposed for sale not to be used for sowing.

One provision sometimes overlooked, relates to farmer-to-farmer sales of seed. The Regulations as to testing do apply to any such transactions. One other point, Northern Ireland has its own legislation relating to seeds and the 1920 Act applies in that country only to the sale of seeds "for a disclosed principal in Great Britain" and to the prohibition of the sale of seeds containing more than a prescribed percentage injurious weed seeds.

Now I turn to say a word on the 1951 Regulations made under the 1920 Act, particularly in relation to injurious weed seeds. These are defined as docks and sorrels, cranesbills, wild carrot, soft brome grass and Yorkshire fog. It is an offence to sell, expose for sale or knowingly sow any seeds to which the Act applies containing more than 5% by weight of these weed seeds. In certain grasses and clover the total percentage by weight of injurious weed seeds must be declared if over 2% and in certain others if over 1%. Dodder must also be declared if present in timothy, flax, linseed and the more common clovers.

Then, let us now look at the legislation on injurious weeds as distinct from injurious weed seeds. For this we turn to the Schedule of the Corn Production Acts (Repeal) Act, 1921. Here the injurious weeds are spear thistle, creeping or field thistle, curled dock, broad-leaved dock and ragwort. Power is given under the Act to serve on the occupier of the land on which these weeds are growing a notice in writing requiring him "to cut down or destroy the weeds in the manner and within the time specified in the notice." I should explain here that the Corn Production Acts, 1917 and 1920 contained

provisions for the destruction of injurious weeds. The 1921 Repeal Act repealed the 1917 and 1920 Acts but preserved in its Schedule modified provisions for the destruction of injurious weeds.

During the past fifteen years there have been changes in the delegation of the Minister's powers under the Schedule of the 1921 Act, but it should suffice to indicate the present position. The councils of county boroughs exercise the delegated powers on non-agricultural land within their areas, the Minister's land commissioners the powers on non-agricultural land outside county boroughs, and the county agricultural executive committees on agricultural land within their areas.

We see then that legislation on injurious weed seeds and injurious weeds dates back to Acts of 1920 and 1921, and though new Regulations under the 1920 Act were introduced so lately as 1st August, 1951, I believe many think there is a good case for a further revision. It is certainly interesting to reflect on the big changes in our methods of growing and processing seeds and destroying weeds since the Acts were passed. We now grow and use a higher proportion of home-grown seed and have extended our seed production to newer crops, e.g. bred strains of grasses and clovers. Crops for seed are now taken outside the old well-recognised seed growing areas. This conference would not be sitting in session today but for the fact that we have witnessed the introduction of revolutionary methods of weed control in recent years. The use of new types of protective seed dressings and crops sprays has become more general. New harvesting machinery, new harvesting methods and more reliable drying equipment have allowed of the harvesting of seed crops which would otherwise have been lost or recovered only through an uneconomic use of manual labour. Then we have a steadily growing list of ingenious equipment and devices in the seed merchant's warehouse to clean out first one and then another weed seed. So rapid has been this last development that occasionally one hears a suggestion, why worry about weed seeds in a seeds crop, they can easily be cleaned out. But I need not pursue that argument. I've no doubt Professor Sanders dealt with it very effectively at this morning's session.

It would be a mistake to think that the influence of those newer developments in relation to existing and possibly new legislation has been overlooked. A good deal of careful study has been and is being given to the problems of weed control not only technically, as this conference well knows, but also in relation to the law. In October, 1949 the Ministry set up a committee on the Qualitative Control of Seeds under the chairmanship of Mr. Frank Horne with the following terms of reference. "To consider what action is possible under the Seeds Act or under amendments to that Act, or otherwise, to introduce practical methods of qualitative control of seeds used in the United Kingdom, whether home-produced or imported." That committee produced a comprehensive report in August, 1950 grouping its main recommendations under two headings (1) those which can be given effect by new or amending Regulations under the Seeds Act, 1920 (2) those which depend on new Statutory Powers. The report has been widely read and studied by various interests - seed growers, users of seed, both large and small, and merchants, and the representative bodies of each have submitted their views to the Ministry. This year the Minister set up a committee on Transactions in Seeds, representative of all the interests concerned with these terms of reference:-

> "To examine and advise on the working of the Seeds Act, 1920, and the contractual relationship between the buyers and sellers of seed with particular reference to proposed measures of qualitative control and the giving or excluding of a warranty of the particulars required to be given on sale."

I can assure this conference that all the members of that committee are desirous of examining the many problems before them with all speed and of reporting as early as possible. Already the committee only constituted last summer, has held three meetings and has made good progress.

I want now to put before you some thoughts on possible lines of discussion not only within this meeting but outside. Seeds Acts either in their present or amended forms must deal with living seed, whose many qualities can seldom be judged accurately by eye or by simple and rapid tests. Quality in seed therefore is a difficult matter to argue in law. But even if the quality of a sample is assured, that value may be more than discounted if it contains many weed seeds of a type which it would be difficult and expensive to destroy once they are established in the soil. It does seem to me, and here I am expressing a personal view, that so far as the main interest of this conference is concerned, there is no need for amendments in the 1920 Act. It should be possible to effect changes to obtain seed more free from injurious weeds by Regulation and without new Statutory Powers. Once the Regulations were amended, it would be desirable to give wide publicity to the guarantees to which the user of seed is entitled. For the Regulations are likely to be more effective, as the user of seed becomes more discriminating in his buying. We do seem to have reached the stage when it is generally agreed that the Regulations do need amending, e.g. at present the wild oat receives no mention.

Now let us look at the law relating to the control of injurious weeds. I am sure there is still a good deal of misunderstanding about the purpose of the Schedule in the 1921 Repeal Act. That Act was introduced when much of the land ploughed out of grass in the 1914-18 war-period was tumbling back to grass. There were many fields full of docks and thistles or where cultivation had been neglected. Numbers of fields formerly agricultural land were lying idle pending development for industry. The main purpose of the Schedule was not to save the indifferent occupier of land from his own neglect, but to protect his neighbours against weed infestation. For a short time I carried out inspections under the Corn Production Acts. That was a long time ago and perhaps too long ago to trust to my memory, but my recollection was that the powers to order the cutting and destruction of injurious weeds were wisely used and were effective in those cases where occupiers had a total disregard for the consequences of their neglect.

Since these days that provision to control injurious weeds has been examined from time to time. There has never been any strong body of opinion in favour of repealing the Schedule. More recently, opinions have been sought as to whether the list of injurious weeds should be added to or amended under the provisions of Section 102 of the Agriculture Act, 1947. Quite a number of suggestions were made to include other weeds, but no revision of the list has yet been made.

That last enquiry did show that there were widely differing views on the value of the 1921 Schedule and indeed as to its purpose. Few, I imagine would doubt the need to have some power to prevent an occupier suffering from the neglect of a neighbour, and this might apply to injurious weeds growing on non-agricultural land or land awaiting industrial development. On the other hand many feel quite strongly that weed control on agricultural land should come within the term 'rules' of good husbandry'. One would hope that as the selectiveness and effectiveness of our modern weed killers improve and their use becomes more widespread, that the need to control injurious weeds by Order would diminish. This certainly seems a more hopeful line of approach than to extend the list of injurious weeds and to serve directions much more widely. The difficulties and cost of effectively administering a more comprehensive scheme of weed destruction would certainly be very formidable. Not only so,

but has not recent experience shown that the cutting or destruction of weeds may be only one step towards ridding the farmer of their nuisance value, whether the land on which they grow be arable or pasture. The real and lasting benefits of cutting, spraying or any other treatment only accrue where by draining and liming if necessary, fertilising, timely cultivations and good stocking an effort is being made to increase production from the land. In short, weed control is a feature of good farm management.

DISCUSSION ON THREE PREVIOUS PAPERS

Mr. F. R. Horne: In a masterly way Sir Edward has portrayed the biological and the dynamic sides of the weed problem, which tend to be overlooked in our natural interest in chemical and engineering aspects. He has shown the factors which determine how weeds achieve success in many of our crops and how they cause so much harm.

The rate of "turnover", if we may use a business analogy, is a big factor. I was surprised at the low multiplication rates of some very common weeds when I first learned of them from Sir Edward Salisbury's own publications. But when one remembers that the rate of increase follows the compound interest law, then I think we can understand how even those weeds with low reproductive capacity can increase so rapidly - when the life cycle is short.

I was interested to hear Sir Edward explain how success as a weed was sometimes related to the fact that separate pollen is not required to produce viable seeds. The examples quoted, Stellaria media and Poa annua, are both species which cause considerable trouble to our seed crops. Annual meadow grass is ubiquitous and may be found in the seed beds of the market gardener, or on the broad acres of the grazier. It is particularly troublesome in ryegrass seed cro crops as chickweed is in white clover.

Sir Edward pointed out the numbers of weed seeds (40,000 an acre) which might easily get into a field at sowing time. We must remember that there may be up to 10 million seeds of the crop plants in a ley, but only 1 - 1¼ million in the sowing of a cereal. In consequence the cereal side is not so good relatively speaking as we might like to think. We have found for example 15% of wheat samples contain cleavers and the 5,000 plants an acre which might result from such samples can cause serious trouble through lodging.

Sir Edward I thought chose an excellent example in tares and lentils, to illustrate natural selection. I found myself hoping that the tares would get so close to the lentils that we would not mind eating them instead! Either that, or we would hope that a herbicide could be found which would differentiate between the two, similar though they might be in appearance.

Pennycress is another troublesome weed from many points of view. In some countries seed containing pennycress may not be imported at all. It provides an admirable example of the way in which a new weed can make our crops much more expensive and can actually debar the grower from part of his market. Can Sir Edward indicate a method of spotting these potentially difficult weeds, whether they come from Kew, Oxford or Cambridge? How are we to recognize them soon enough to control them before they go too far?

Another example of a new weed is Crepis taraxacifolia, the dandelion leaf hawk's beard. This is a very active, and aggressive type which takes two years to complete its life-cycle. It has spread along the railway banks and then into the meadows where it greatly reduces the value of the hay crop.

Mr. Coleman has given us a very interesting account of dispersal by machinery. He quite rightly stressed the grass side.

It is the association between management and the characteristics of the weed that are important. I should like to see the effects of early cutting and rotation of the land between grazing and hay included in the studies which Mr. Coleman very rightly advised. The few observations I have made suggest that the date of cutting has an enormous effect on the amount of seed dispersed.

Perhaps the binder got off rather lightly in last year's discussion on methods of distributing weed seeds but we certainly need very much more data on the combine. I am not at all sure that American data is particularly relevant in this country because of big differences in the weed flora and in dormancy problems and the much heavier yields of straw in Britain.

The A.R.C. Unit at Oxford with the N.I.A.E. and ourselves at the N.I.A.B. have decided that this is a problem well worth careful study. Unfortunately some of this year's observations were made difficult by the weather. However a programme has been started and we should be able to answer some of Mr. Coleman's queries before long. But it is not enough to study only a single aspect of the combine. This machine tends to alter the whole farm system and a very comprehensive survey would be required to assess its full effects. When a man buys a combine he often reduces his manpower and grows a slightly bigger cereal acreage in order to use the combine fully. This affects his rotation and a chain of events is started which, collectively, may have a very marked effect on the weed population of the farm.

Sir Edward started by mentioning dormancy in seeds but did not go on, as I hoped he would, to say something of weeds and crops so familiar to him where dormancy is important.

Mr. Dadd dealt extremely well with Mr. McMillan's paper. It is never easy to read someone else's paper and to make it sound alive. The two main points now being looked at, and on which members of this Conference might wish to express an opinion, are the species included in the lists of injurious weed seeds in seed samples and injurious weeds in crops. If you look at the old list of weed seeds it savours very much of grass crops. Yorkshire fog, soft brome, wild carrot, the geraniums and, even, the sorrels and docks tend to be much more serious in grass or clover than on arable land. On the other hand such important species as shepherd's needle, wild oat, wild onion, corn-cockle and wild radish, many of which could be hit, and hit very hard, by herbicides, are entirely omitted from the list. I would like to hear what other members feel about the present list and I would like to ask Mr. Dadd whether he thinks that the fact that we now have methods of dealing with these weeds is an argument for raising the permissive standard or for lowering it?

Sir Edward Salisbury: The Chairman has suggested that I should answer these questions straight away. First of all, with regard to this matter of spotting the potentially aggressive weed. Well, there is this question of infection pressure. We have already shown that this is very real but that does not mean that we know what it is in fundamental terms. Perhaps I might venture to mention an experience I had which will give you an idea of one way, and I am not suggesting that it is the most important way, in which infection pressure may operate. Has it ever occurred to you, it certainly did not to me before this experience, that slugs have their likes and dislikes, their feelings of palatability for certain weeds and their desire like a human being to have a fresh dish on the menu? Some years ago I was doing some research on Ranunculus parviflora. I wanted a lot of seedlings so I sowed patches in my garden at Radlett. They germinated very freely, and to my annoyance I found

two mornings later that the slugs had come and eaten them completely up. So I sowed some more and the same thing happened. I used various barrier devices to prevent slugs, but they were not discouraged; they were so anxious to try to eat these Ranunculus parveflora seedlings that they went over the barrier, some of them died, some of them got over and ate my seedlings; but this was the extraordinary thing, I went on sowing patches and I found that after a while they were left completely alone. You can see how this preference of slugs or other herbivorous animals might operate to prevent the advent of a new species until it was present in sufficient quantity so that it saturated the taste of its predators. That is merely one way but there are many others. I might mention once again in connection with your question that Veronica filiformis now bids fair, owing to its vegetative characteristics, to being a rather aggressive weed. How did that come into this country? Well, it was deliberately introduced into people's rock gardens because they thought it was such a beautiful plant, and really did not get out into the country as a weed until it had already been established in hundreds, if not thousands of rock gardens throughout the country. One can obviously get some sort of indication of the potential aggressiveness of a weed by estimates of its reproductive capacity and its capacity for vegetative multiplication, but, then you are up against the fact that a weed which comes into this country may not always set seed, as for example the American Ambrosias. The other point that Mr. Horne raised was in connection with naturally dormant weed seeds within the species. We are all familiar with the hard and soft seeds of leguminous plants and we know that there the distinction between them is a genetic one, you can get strains that have a high or low proportion of hard seeds, which are the dormant ones, but when you come to some of the other species that produce dormant seeds the problem seems a very complicated one. For instance, we know that in many seeds dormancy is determined by certain characters of the testa. The testa is perhaps impervious to water or relatively impervious to gases, but many years ago some research students of mine investigated the dormancy in one species of plant in which you found that the more seed you sowed and the more batches you studied, although you tended to get a closer approach to a normal variation curve, in fact this normal variation curve was made up of a lot of peaks and it was only when you joined the tops of the peaks that you got a smooth normal distribution. Since when the testa was removed you got simultaneous germination it was clear that the factors concerned were in the testa, but why was it that these intermittent germinations were manifest irrespective of the number of seeds sown? It obviously is not a continuous variation of testa thicknesses and one suspects there is a combination of several factors of which the testa structure is only one and the presence of inhibitor is another, but even so more factors still are required to give you that intermittent variation curve.

Mr. M. V. Grant: I would like to ask Sir Edward Salisbury about the dispersal of seeds by water. I have in mind a particular example in the Midlands, in the Trent region, where ditches and fields are periodically flooded. Some of the chief weeds seem to be broad-leaf docks and perennial nettles. Are there any methods of combating this means of dispersal?

Sir Edward Salisbury: I really do not think there are. There is no question that dispersal by water is a very important factor. I do not mean merely the dispersal by floating down ditches but rain wash is quite important as a subsidiary means of dispersal for many plants which have as their primary means of dispersal some other method. I think the question you raised does call attention to a very important point and that is that there are quite a number of plants, and I am discovering more and more of them every day, which have, more than one method of dispersal; or if they rely on one method of dispersal the seeds they produce vary in such a way that the dispersal is of two kinds. To mention one striking example, common orache (Atriplex patula) which is such an abundant weed, has the terminal fruits mostly distributed by the wind,

whereas the smaller seeds which look quite different from the others are dispersed by birds. With the garden orache, Atriplex hortensis, the two types of seed are so different that if anybody did not know anything about it and you showed them both, they would think you were a liar if you told them they came from the same plant.

Mr. O. G. Williams: From time to time we see offered in the market seed cleanings which contain many injurious weeds. I am thinking particularly of blackgrass which, it is said, can be sown perfectly safely in areas outside its natural distribution. Does Sir Edward feel that our climatic conditions in this country vary to such an extent that there would be an area where it would be perfectly safe to sow cleanings containing blackgrass?

In the iron stone areas of Northampton, sub-surface soil from a depth of about 80 ft. below ground is brought up to the surface and piled in heaps. Although this soil is presumably perfectly sterile, it is quickly colonised with certain weeds. The most frequent is coltsfoot, (Tussilago farfara), and as far as I know there is not normally a very high population of coltsfoot in that area. Another rather similar situation is where gypsum is mined. In the gypsum area around Newark within two or three years the sub-surface soil is colonised almost to the exclusion of anything else by Melilotus officinalis. In this district we do not normally see many wild plants of Melilotus officinalis.

Sir Edward Salisbury: As regards the seed cleaning, I should be very hesitant to sow seed cleanings on the assumption that none of the species it contained would grow, unless those seed cleanings came from the tropics. After all the capacity for species, as we well know at Kew, from even sub-tropical regions to survive our climate is sometimes remarkable. You sometimes find a plant which is normally associated with sub-tropical conditions that will grow quite comfortably in this climate. It may produce only a comparatively small number of seeds and so it might not become a pernicious weed, but I should be very hesitant about sowing the two species to which you refer. I should suspect that birds carry the Melitotus to your Gypsum area. With regard to Coltsfoot, there is no question about it that the fruits of this weed are carried many miles by wind. You can never be certain that any bare area might not be colonised by coltsfoot in that way. If you test, as I have, the rate of fall of various seeds in a still air tower, like the pagoda at Kew, you will find that the rate of fall of the fruits of Coltsfoot is very slow and, consequently, if they are carried up by a convection current there is a very considerable prospect, which I referred to in my paper, of their being caught up by a wind. In this way they may be carried 50 or 100 miles before they come down. That is the long distance secondary spread to which I referred and there is no doubt that that is how your bare areas got colonised with Coltsfoot.

Miss J. M. Thurston: We have heard a lot this afternoon about dispersal by machinery and people's clothing. From my wild oat work, I can add another method and that is dispersal in sacks. We met it very commonly at Rothamsted when we were collecting seeds from different parts of the country. In consequnece, we have to be very careful what we use those sacks for afterwards. In one instance the introduction of wild oats was quite definitely traced to sacks that had picked up the wild oats from infested corn and were subsequently used to transport fertiliser to a clean field.

Mr. Horne mentioned that Mr. Broad's work has shown from the seed samples submitted to the N.I.A.B. that seed cleaning methods were reducing the amount of certain types of weed seeds in seed-corn, among them wild oats. But the

N.I.A.B. are only concerned with samples sent in for analysis by people who are careful about what they are putting in with their seed corn. Samples drawn fr from farm to farm sales or from home grown seed would no doubt show a much higher percentage of weed seeds. It is still common to find fields where wild oats occur actually in the drill rows indicating that they have been sown with the seed.

I was interested to note that Sir Edward thinks that pigeons are the villains of the piece in spreading a number of weed seeds. Has he any view on rooks and seagulls as spreaders of weed seeds?

Sir Edward Salisbury: I have no knowledge whatever as to the efficiency of seagulls as distributors of weed seeds. They may be quite important, but I have not seen any evidence anywhere as to what their droppings contain, but the late Mr. Woodruff Peacock got some very good evidence as to the importance of rooks as dispersers of seed and in some rook droppings he found that quite a large number of common weed seeds emerged when he sowed droppings on sterile soil.

Mr. S. J. Willis: Sir Edward mentioned the spread of weed seeds in dung. I wonder if he could briefly comment on the likelihood of spread in compost and sewage sludge. Both these methods of dispersal appear important, the latter particularly for Polygonum persicaria.

I wonder whether Mr. Coleman would care to make any observations on whether the removal of mud from the wheels of farm implements, in order to prevent the carriage of weed seeds from field to field, is a practical proposition.

Sir Edward Salisbury: I don't suppose there are any of the "muck-minded" here so I needn't hesitate to say that in my experience the presence of weed seeds in compost is far worse than it is in manure. In the manure you do have the chance of high temperature to kill them but in compost you don't.

Mr. F. Coleman: I cannot see any practical way of preventing what I call the fortuitous spreading of weed seeds in the mud on wheels or lodged in crevices on implements. The amount of manpower that would be required to clean them down would be far too great to be contemplated.

Mr. C. V. Dadd: Mr. Horne asked if I thought that the standards for weeds in cereal seeds should be raised or lowered in view of our ability to control more weeds chemically now than hitherto. I would answer that without hesitation "Raise the standards, do not lower them." The standards do not stand very high at present in respect of cereal seed. I feel quite strongly that many farmers have got to be protected from themselves in this respect. I am sure that there are relatively few farmers who appreciate that the Seeds Act applies to farm sales of seed. Too much seed is sown "straight from the drum" without a careful examination for certain weeds.

In connection with any new schedule or other arrangements for improving the cleanliness of cereal seeds is the need to drive home to the farmer by every possible means a realisation of the importance of ensuring that he is sowing clean seed. I specify cereal seeds particularly for local reasons, but my point applies to all seeds. There are several ways of doing this; one is by having more than one standard laid down in the schedule of this Act. This might lead to a seedsman offering seed for sale of different grades in respect to its cleanliness. I am quite sure that there are many farmers in my Province who would pay several shillings extra per cwt. to be quite sure that they were buying cereal seed free of wild oats. Such farmers are in the

minority, but they wisely realise that a few seeds of this weed will start an infestation. In this connection I agree with Miss Thurston that there is far too much home saved seed that contains wild oats.

I often wonder how important sacks really are in transmitting wild oats. I know full well that wild oats will stick in the corner of sacks, but I am not so satisfied that this method of dispersal is really important.

Sir James A. Scott Watson: I am very happy to propose a vote of thanks to our three speakers. Mr. Macmillan is in the United States and has expressed his sorrow at having to miss this Conference but these national contacts are extremely important. We're very fortunate in this Conference to have so many people from overseas and we must expect to give as well as to gain.

I'm delighted to see a representative from the Royal College of Agriculture back in the research field. The tradition of the old Royal College is a very great one in research as well as in other fields. One thinks in particular of some of the early soil research by Way which was quite epoch-making work and was done at this college. Unfortunately the College had to be closed during the war. We're all delighted to see it coming back so prominently in the teaching field and we're very glad to think that research is active there and we would like to compliment Mr. Coleman on the very interesting work he is doing.

I know how heavy a burden Sir Edward Salisbury is carrying. I think the work which he does in his spare time, for the Royal Society, is very heavy indeed and the responsibility of looking after Kew is a very fulltime job. We're glad to see him this afternoon. He's made, first and last, an immense contribution to plant ecology and I think we all envy him his powers of exposition, not only in the spoken word but also in the written word. I say that because long before I had the pleasure of getting to know him personally, I read one of his earlier books called "The Living Garden" and I think that is a model of putting very sound and even rather highbrow science in terms that the ordinary man in the street can understand. We do thank you very much for coming along here this afternoon, Sir Edward, and hope that this will not be your last contribution at the Weed Conference.