McDONALD INSTITUTE CONVERSATIONS

Far from the Hearth

Essays in Honour of Martin K. Jones

Edited by Emma Lightfoot, Xinyi Liu & Dorian Q Fuller

Cover image: *Foxtail millet field near Xinglonggou, Chifeng, China, photographed by Xinyi Liu, September 2014.*

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Chapter 2

The Fighting Flora:
An Examination of the Origins and Changing Composition of the Weed Flora of the British Isles

Chris J. Stevens & Dorian Q Fuller

The nature of charred assemblages

With the application of flotation to archaeological sites across much of Europe and the Near East, it quickly became apparent that charred assemblages appeared to be remarkably uniform, comprising wood charcoal along with charred grains, cereal chaff and seeds of species often commonly associated with arable fields (Jones 1985; Knörzer 1971). It was these wild species seeds, the charred seeds of agricultural plants which were to form a large part of Martin Jones' work, that we explore further here, drawing on changes within the weed flora, and the picture it paints of the history of agriculture within the British Isles.

The nature of competition

One of the major contributions of Martin Jones was the discussion of the reproductive strategies of weeds, in particular those associated with dormancy, germination and the formation of seed-banks and how they related to past agricultural practice (Jones 1981; 1984; 1988a,b; 2009).

Agriculture by its very nature produces disturbed environments through tillage, by spade, ard, plough, hoe and/or harrow. For perennial species, unless they are able to reproduce seed within a single season, survival in the arable field relies on seasonal reproduction through vegetative means or simply through avoidance within low disturbance tillage regimes, for example by ard. In contrast, annual species had already evolved a number of strategies to colonize disturbed habitats, by which they were eventually able to dominate arable fields. For annuals and perennials one strategy to colonize disturbed soils was through appendages attached to the seed, dispersal mechanisms that facilitated the finding of recently vacated suitable microsites for germination. The other strategy was through the formation of seed-banks comprising seeds buried within the soil. These buried seeds often require certain conditions before they will germinate, known as dormancy mechanisms. These mechanisms delay germination, allowing the plant to disperse their seed temporally. In this way seeds buried in the seed-bank can seek out suitable moments when conditions are favourable for germination to establish a new plant.

On the basis of seed persistence and dormancy breaking mechanisms four seed-bank types have been defined (Grime *et al*. 1988; Thompson & Grime 1979).

Transient seed-banks
Type I: Seeds lack dormancy mechanisms, germinating shortly after shedding. Often no light requirement. Seeds have little longevity in the soil.
Type II: Seeds possess dormancy breaking mechanisms, for example chilling, after which there is often no light requirement. Usually germinating in early spring, but can be in winter. Seeds have little longevity in the soil.

Persistent seed-banks
Type III: Most seeds germinate shortly after shedding, but some enter dormancy, forming a persistent seed-bank.
Type IV: Most seeds are dormant and few germinate directly after shedding. Colonization is from a large maintained seed-bank with little seasonal fluctuation in its size.

Type I seed-banks predominate within large-seeded grasses, for example *Bromus* sp. (see Table 2.1; Thompson & Grime 1979), and are associated with dry-grassland ecologies, with predictable seasonal disturbance, where vegetation dies off in the dry summer. Dispersal via awns and germination with the next rains are essential to the plant's survival to the next generation. Such habitats are found within

the grassland steppe of the Near East and the natural grasslands of central Europe. Seeds of Type I species are shed prior to and during harvest, and would germinate either prior to autumn tillage, or potentially after sowing (Fig. 2.1). As such they can potentially survive within the arable field under autumn sowing. However, such species would more likely be removed by tillage, hoeing or weeding prior to spring sowing (Fig. 2.2) and hence, if not harvested then reintroduced with seedcorn, would be absent within spring-sown fields.

Type II seed-banks are associated with species inhabiting northern temperate and continental zones, evolving in situations where seasonal annual disturbance, perhaps relating to water-erosion, solifluction or frost-heaving, can lead to vegetation openings during winter and spring (Thompson & Grime 1979). Examples include *Galium tricornutum* (corn cleavers) and *Agrostemma githago* (corncockle), probably native to the mountains of the Near East and Mediterranean regions, respectively (cf. Ehrendorfer & Schönbeck-Temesy 1980, 607–8; Greuter 1995). For both species, seed germination increases after 'chilling' at lower temperatures *c*. 4–6°C (Chauhan *et al*. 2006; de Klerk & Smulders 1984; Steinbauer & Grigsby 1957), as occurs in their natural habitats during winter. This same requirement was also seen for the British native *Galium aparine* (cleavers). In the arable field such mechanisms allow seeds shed in summer potentially to avoid autumn ploughing (Fig. 2.1), but they are likely to be destroyed by spring ploughing (Fig. 2.2) and hence are potentially good indicators of autumn sowing (see Jones 1981). *Agrostemma githago*, however, can appear after spring sowing, possibly due to an after-ripening period that removes the need for chilling within dry storage (cf. de Klerk & Smulders 1984), something that might occur if it was stored with, then resown as, a contaminant of the seedcorn.

By the nature of their lack of longevity, seeds of species with Type I and II seed-banks tend not to become buried, and are often larger in size. Within the agricultural field, such species might germinate before tillage, hence they are often reliant on being harvested and resown with the crop, characterized by being of similar height and possessing grain-sized seeds.

Species displaying Type III seed-banks might be thought of as evolving within environments characterized by regular, but more sporadic, catastrophic disturbance, for example flooding or fire, which destroys much of the vegetation before it can set seed. This strategy allows them to germinate quickly and continue to dominate such environments without the need to recolonize from adjacent habitats. Seeds of such species can be variable in size, for example *Poa*

as opposed to *Lithospermum arvense* (field gromwell). It is also notable that while after-ripening is required, 90 per cent of *Lithospermum arvense* seed germinates within the first year, suggesting recruitment to the arable field is predominantly through continued production of seed rather than the seed-bank (Chantre *et al*. 2009). Within the arable field, Type III species, given their tendency to germinate after shedding, as with Type I species, might well be expected to be more greatly diminished under spring sowing regimes (Fig. 2.2) than autumn.

Type IV species usually produce high numbers of small seeds, for example, *Chenopodium* spp., *Juncus* sp., *Stellaria media*, although others such as *Fallopia convolvulus* (wild buckwheat) have much larger seeds. They are adapted to environments where disturbance regularly occurs, but is unpredictable both in its seasonal timing and that such disturbance may not occur every year.

To summarize, species with transient seed-banks are more likely to persist where they are harvested with the crop then resown with the seedcorn through broadcast sowing, a method of sowing that dominates ethnographic and historical accounts (e.g. D'Andrea & Haile 2002; Hillman 1984; Murray 2000). Type I species are generally associated with autumn germination (Fig. 2.1) and Type II with spring, although as seen above this is not always the case (Fig. 2.2). Species with semi-persistent seed-banks (Type III) will potentially be able to survive periods of grazing and tillage. However, where fields are left fallow but still tilled and harrowed, or planted in rows and regularly weeded, they will be much reduced, unless by virtue of having large seeds they are able to be resown as contaminants of the seedcorn. Species with persistent seed-banks Type IV might be expected to be lower where cultivation regularly shifts to new plots, or with the use of the ard, which unlike asymmetrical shares neither cuts deep nor turns the soil burying the seed (Figs. 2.3, 2.4). However, with the use of the plough they are much more likely to increase as the plough buries newly shed seed and brings those buried, but which have lost their dormancy, to the surface (Fig. 2.4; Fay & Olsen 1979).

The second aspect is the relation of perennials and annuals to tillage and rotation with pasture (Figs. 2.3, 2.4). The situation is complex, not least because of incomplete knowledge about the ability of perennial species to produce seed in their first year and so escape cultivation by behaving more like an annual than perennial. For example, *Plantago major* (broadleaf plantain or white man's foot) may produce seed within six weeks of germinating from a persistent seed-bank (Holm *et al*. 1977). However, where perennial plants
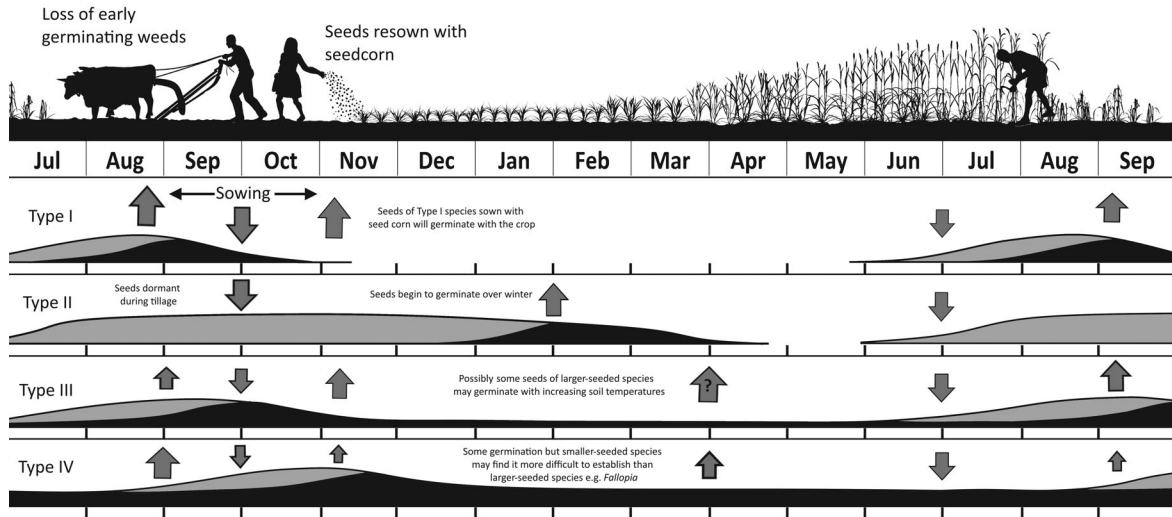
Figure 2.1. *Diagrammatic representation of seed-bank types (includes annual and perennials) from Thompson and Grime (1979) denoting additions (down arrows) and losses (up arrows) from the seed-bank within an autumn sowing-tillage cycle. Black areas denote seeds capable of immediate germination with suitable stimuli, grey areas viable seeds that are dormant and not capable of immediate germination.*
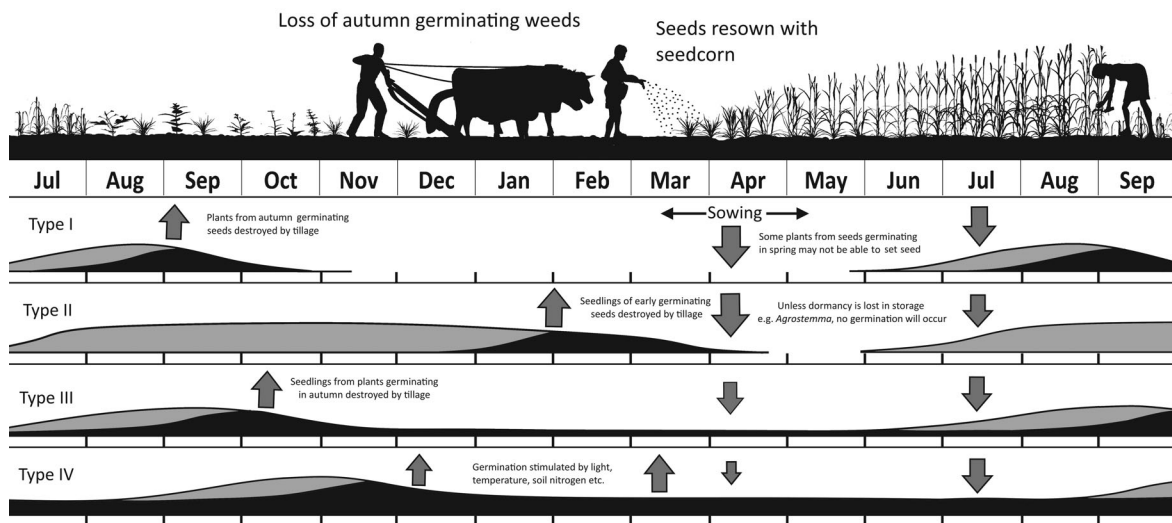
Figure 2.2. *Diagrammatic representation of seed-bank types (includes annual and perennials) from Thompson and Grime (1979) denoting additions (down arrows) and losses (up arrows) from the seed-bank within a spring sowing-tillage cycle. Black areas denote seeds capable of immediate germination with suitable stimuli, grey areas viable seeds that are dormant and not capable of immediate germination.*

although equally it may be that the grazed grassland floras, that when cultivated gave rise to high numbers of perennials within arable fields, were also not well established at this time (see Fig. 2.5). Further, the high presence of species with transient seed-banks would seem contrary to highly intensive systems in which grains are suggested to have been planted individually in rows (see Kluyver *et al*. 2013; Kruez & Schäfer

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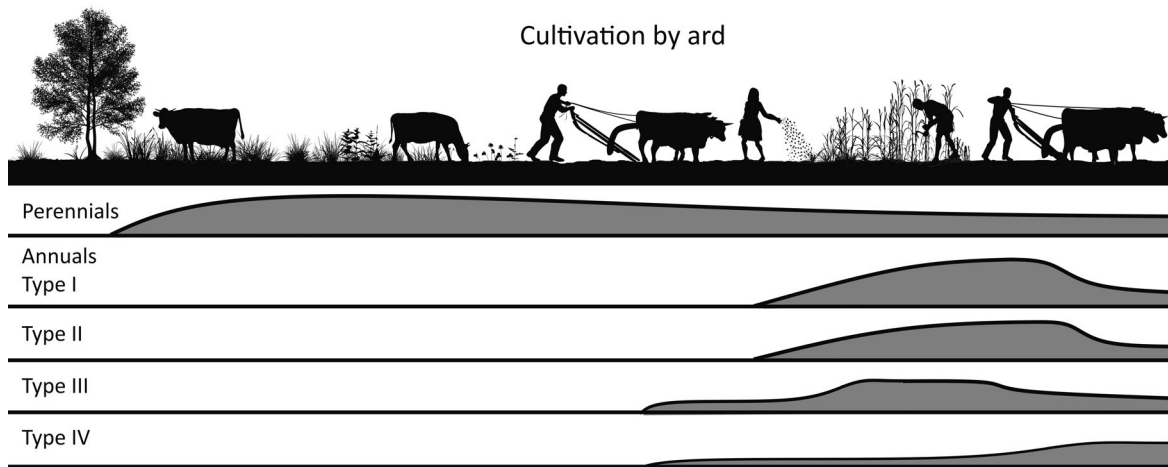
Figure 2.3. *Relative presence and persistence of perennial species and annual species of seed-banks Types I–IV in the field, following a period of pasture under successive seasons of ard cultivation.*
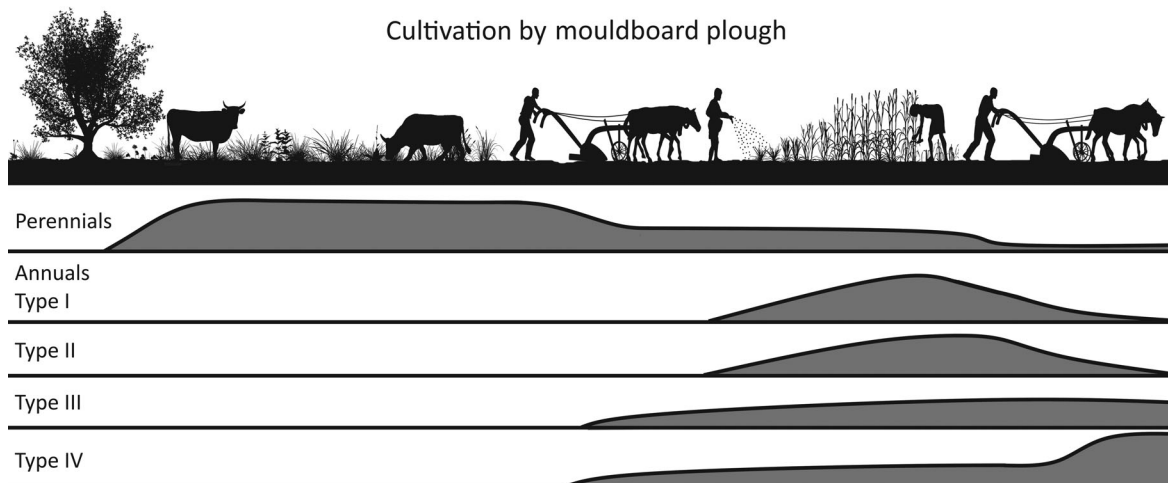
Figure 2.4. *Relative presence and persistence of perennial species and annual species of seed-banks Types I–IV in the field, following a period of pasture under successive seasons of cultivation with a mouldboard plough.*

are untouched by minimal tillage regimes, for example ard tillage, they will have less reliance upon survival by regeneration from seed or be able to persist to set seed in subsequent years. Conversely, asymmetrical ploughs will 'lift' such plants and turn them over, exposing their roots to drying. Therefore we might expect perennials to decline in the arable field where soil disturbance is deeper, and for longer durations. For this reason perennials have often been seen as indicators of ard cultivation or ley farming, while high percentages of annual species are interpreted as indicators of mouldboard ploughing (Hillman 1981).

Identifying archaeophytes

In terms of prospective pathways towards the formation of the British arable weed flora, we may delineate two components; indigenous species found in natural habitats that adapted to arable fields, and introduced species spread as contaminants of cereal grain or commensals of habitation. Prior to the formation of the English Channel some 8000 years ago, the main means by which new species could reach the shores of Britain and Ireland was through people or with the animals they brought with them. The species that arrived

before AD 1500, the beginning of the modern era, have traditionally been termed archaeophytes. The first serious consideration of archaeophytes within the British Isles was conducted within the nineteenth century (Henslow 1835; Watson 1847–59). This was later revisited by Godwin (1975) and more recently by Preston and colleagues (2004), using the growing body of work available on pollen and macro-remains in order to disentangle the native from the introduced.

We have compiled a list of common weeds recovered from archaeological sites within the British Isles (Table 2.1), together with ecological information pertinent to how they spread into the first arable fields and ecological and physiological information pertaining to how they maintained a viable population and were affected by subsequent cultivation regimes.

Several factors come to light in examining this record. The first is that many potential archaeophytes have a distinctly southeastern (Salisbury 1961; Webb 1985), or uneven distribution, especially with regard to Scotland, Wales and Ireland. The second is that within Europe many have a distinctly southern temperate to Mediterranean-Atlantic distribution. The final point is that many of these potential archaeophytes, as might be expected, lack 'natural' non-anthropogenic habitats within the British Isles. In terms of local recruitment, it has long been noted by Martin Jones that many of the weeds species found associated within prehistoric fields are naturally associated with coastal, riverine and/or woodland habitats. Finally, the majority of the species listed within Table 2.1 as possible aliens are generally also not considered native within other European floras (Preston *et al*. 2004; Webb 1985).

One difficulty with the use of waterlogged and pollen records in identifying native flora is the absence of species that are uncommon in wetlands. Further, seeds of the Poaceae and Fabaceae are difficult to identify and rarely survive in waterlogged deposits; hence the native status of species within these families remains particularly problematic.

Further as to the routes by which these species might have arrived in the British Isles we must also consider the following points:

Number and nature of likely incursions (migration, trade, redistribution and transport of grain through taxation)

Probability of weed seeds being transported within seedcorn (affected by harvesting methods, species height and processing, e.g. grain size and dispersal mechanisms, if sieved or shaken in baskets)

The probability of an individual species, including native species, by virtue of their ecological parameters becoming permanently established within the local arable weed flora.

Given the focus on trade, taxation, migrations and agricultural practice the incursions of weed flora as such can be seen to be reflective of the greater political and economic landscape of Europe.

The first wave of weeds

Unlike Neolithic assemblages on the continent which can be relatively rich in the number of seeds and taxa (Kruez & Schäfer 2011), the number of weeds recorded for the Neolithic in the British Isles is extremely low. Dismissing possible intrusive elements (see Pelling *et al*. 2015; Stevens & Fuller 2012) the more certain introduced weeds include *Fallopia convolvulus* and *Avena fatua* (common wild oat). *Bromus* is also common but rarely identified to species, although it seems probable that both *Bromus secalinus* (rye brome) and *Anisantha sterilis* (bromegrass) were introduced at this time. *Bromus hordeaceus* (soft brome) is considered native to Britain on the basis of coastal subspecies (cf. Preston *et al*. 2004), but its ecology and reproductive strategies are similar to those of *Bromus secalinus*. A similar situation also exists for Neolithic finds of *Vicia* and/or *Lathyrus*, in part because of difficulties in identifying charred material to species—for example, *Vicia sativa* (common vetch) like *Bromus hordeaceus* has a coastal sub-species, *Vicia sativa* subsp. *nigra* (L.) Ehrh.—but also because of the difficulty of recovering identifiable macrofossils, which for both grasses and leguminous species rarely survive in waterlogged deposits. The last example concerns *Galium*, which presents a similar, but slightly different set of problems. Most macrofossils are assumed to be of *Galium aparine*, a likely native species of coastal regions and woodland edge; however distinguishing this species from *Galium tricornutum* or *Galium spurium* (false cleavers) is problematic. *Galium tricornutum* is thought to be a Roman to Medieval introduction, while *Galium spurium* is thought to be introduced after AD 1500 (see Hill *et al*. 2004); a curious situation, given that *Galium spurium* is relatively common in charred assemblages from Greece all the way to northern France (Bakels 1999; Coward *et al.* 2008; Knörzer 1971). Finally, there arises the question of whether the genetic lineages of those plants that occupy anthropogenic environments are in fact closer to once existing native species, or if rather they comprise new lineages containing arable adapted phenotypes which evolved on the continent.

What is noticeable is that many of the weed species recovered from British Neolithic sites, including native species, are large-seeded and reach similar heights to the crop. Some, such as *Persicaria maculosa* (lady's thumb), can be slightly shorter, while others, for example *Chenopodium album* (goosefoot), and pos-

Table 2.1. *Common weeds within British archaeobotanical assemblages.*

Species	Seed size mm	Life cycle	Height cm	Native status, Earliest date	Main distribution (K value)	Naturalized habitat
Adonis annua	L	A, 2/?3	40	Ar, LIA/RB	SE Eng (9)	0
Agrostemma githago	G(H)	A, ?2	100	Ar, LIA/RB	Eng (–)	0
Anisantha sterilis	G (A)	A, 1	80	Ar, Neo	Eng, W Ir (8)	0, 6
Anthemis cotula	S (H)	A, 3/4	60	Ar, LIA/RB–	C, E, SE Eng (8)	0
Atriplex patula	S(A)	A, 2?4	87	N, [?Neo] MLBA	Widespread (6)	(1), 6
Avena factua	G (A)	A, 1?3	150	Ar, Neo	Eng, W Ir (–)	0
Bromus hordeaceus	G (A)	A, 1	80	?N ?Ar, ?Neo	Widespread (8)	3 (ssp. 1)
Bromus secalinus	G (A)	A, 1	90	Ar, ?Neo	S, C, E Eng (–)	0
Centaurea cyanus	G (H)	A, 2	80	Ar, RB	Eng, E Sc (7)	0, 6
Centaurea nigra	G (H)	A, 2	80	?Ar, RB	Widespread (7)	3
Chenopodium album.	S	A, 4	100	N, Neo	Widespread (6)	(1), 6
Chrysanthemum segetum	G	A, ?3	60	Ar, ?IA/RB	Widespread but patchy (8)	0
Cirsium arvense	I (H)	P, V ?3	120	N, Neo	Widespread (7)	3, 6
Cirsium vulgare	I (H)	P, 1	150	N, Neo	Widespread (7)	3
Eleocharis palustris	S (A)	P, V, 3/4?	60	N, [Neo]/MLBA	Widespread (6)	2
Fallopia convolvulus	G	A, 4	100 T	Ar, Neo	Eng, Wa, E Sc, W Ir (6)	0, 6
Fumaria murialis	G	A, ?4	100	?Ar, MLBA	Wa, S Eng, W Ir, NE Eng, E Sc (8)	–
Fumaria officinalis	G	A, ?4	52	Ar, MLBA	Eng, Wa, E Sc, W Ir (8)	0, 6
Galium aparine	G (A)	A, 2	150 T	N, Neo	Widespread (7)	1, (4), 6
Galium spurium	G (A)	A, ?2	100 (T)	Ar, ?LBA/RB	Rare, SE Eng (7)	0
Galium tricornatum	L/G (A)	A, ?2	50 (T)	Ar, Sax?	SE Eng (8)	0
Lapsana communis	G (H)	A, 3	95	?N, [Neo] RB/Sax	Widespread (7)	0, 6, (2, 4)
Lithospermum arvense	G	A, 3	50	Ar, LBA/IA	SE, C, E Eng (8)	0
Lolium perenne	I/G (A)	P, 1	50	?N, BA	Widespread (8)	(2), 3, 6
Lolium temulentum	G (A)	A, 1	90	Ar, med	Rare, C Eng (–)	0
Malva sylvestris	I	P, ?3	150	Ar, MLBA	Eng, Wa, SW Ir (8)	0, (4), 6
Montia fontana	S	P, ?4	20	N, [Neo] MLBA	Wa, SW, SE, NE Eng, NE Sc (5)	2
Odontites verna	S	A, 3	50	N, IA	Widespread (7)	1, 3
Papaver dubium/rhoeas	S (H)	A, 4	60	Ar, ?MLBA	Eng, E Sc, SW Ir (8)	0, 6
Persicaria maculosa	I/G	A, 4	80	N, Neo	Widespread (7)	(2), 6

sibly *Atriplex*, grow to similar height, but have small seeds. However, these are generally less common, as are those of other low-growing native species, *Polygonum aviculare* (knotgrass), *Stellaria media* (chickweed), *Plantago lanceolata* (English plantain) and the archaeophyte *Urtica urens* (annual nettle)—the last, recovered from southeast England (Hunter 2012), represents the first record for this species.

The predominance of tall, large-seeded species might then suggest that crops were harvested relatively high on the culm, as Knörzer (1971) originally suggested for *Bandkeramik* sites. Likewise the predominance of large weed seeds might also indicate that small weed seeds were removed after harvest, perhaps through the use of winnowing baskets, as

such seeds fall through the holes between the weave. An absence of chaff generally in the Neolithic has led to the suggestion that crops were stored in a highly cleaned state (Stevens & Fuller 2012). It might also be that harvesting high on the culm brings in fewer weed seeds. More recently a difference noted between LBK I and LBK II sites was attributed to a change in harvesting strategies (Kruez & Schäfer 2011); for example, numerous seeds of *Veronica arvensis* (wall speedwell), a small-seeded, low-growing weed, from LBK II sites suggest harvesting low on the culm. Curiously, this species is regarded as native in the British Isles despite the first record not being until the Iron Age (van der Veen 1992), but is seen as a Neolithic introduction on the continent (cf. Preston *et al*. 2004).

Table 2.1. *(Continued.)*

Species	Seed size mm	Life cycle	Height cm	Native status, Earliest date	Main distribution (K value)	Naturalized habitat
Plantago lanceolata	I/G	P, Vs 3	15	N, ?Neo	Widespread (8)	1, 3, 6
Poa annua	S	P, V 3	20	?N, IA	Widespread (6)	1, 3, 6
Polygonum aviculare	I/G	A, 4	30	N, Neo	Widespread (6)	1, 6
Prunella vulgaris	S	P, Vs 3	30	N, [Neo] MLBA	Widespread (6)	3, (4)
Ranunculus acris	G	P, V 3	75	N, MLBA	Widespread (3)	(1, 2), 3
Ranunculus repens	G	P, Vs 3	60	N, MLBA	Widespread (5)	(1, 2, 4), 3, 6
Rumex conglomeratus	S/I (A)	P, ?4	60	N, [Neo] MLBA	Widespread (8)	2, 3
Rumex crispus	S/I (A)	P, ?4	100	N, [Neo] MLBA	Widespread (8)	1, 2, 3, 6
Sherardia arvensis	I (A)	A, ?2	40	?N, MLBA	Wa, Eng, SW Ir (8)	(1), 3, 5
Stellaria media	S	A, 4	50	N, Neo	Widespread (6)	1, 6
Trifolium repens.	S	P, Vs 4	20	N, MLBA	Widespread (5)	3, (6)
Trifolium pratense	S	P, 3	45	N, MLBA	Widespread (7)	3
Tripleurospermum inodorum	S	A, 3 Vs	60	Ar, MLBA	Widespread (7)	0, 6, (5)
Urtica diocia	S	A, 4	150	N, Neo	Widespread (5)	2, (3,4), 6
Urtica urens	S	A, 4	60	Ar, ?Neo	Eng, less Ire, Wa, Sc (8)	0, 6
Veronica arvensis	S (H)	A, 3	25	?N, IA	Widespread (8)	0, 6
Valerianella dentata	S/I	A, ?2	15	Ar, MLB	SE, C, NE Eng (7)	0
Vicia sativa	G (H)	A, ?4	90 T	?N, Neo	Widespread (8)	1, 5, 6
Vicia tetrasperma	I/G (H)	A, ?4	60 (T)	Ar, ?Neo/IA	S Eng, Wa (7)	(1), 3, (4), 6

Average seed size: L=Large/spikelet-sized >4–5 mm; G=Grain-sized >2.5 mm; S=Small <2.5 mm; I=intermediate 2–2.5mm; A=Appendages (awns, bracteoles, bristles, etc.) that might increase seed size, or H=headed or seeds released in pods/capsule resulting in grain contamination (Grime *et al*. 1988; Stace 2010).
Life cycle: A=Annual; P=Perennial; Seed-bank type (1 & 2 transient; 3 & 4 persistent); V=Vegetative reproduction; Vs=Seasonal vegetative reproduction.
Height: Maximum height in cm; T=twinning, climbing, scrambling habit; (T)=less pronounced habit.
Native status: Ar=Archaeophyte; N=Native. **Earliest date**: Neo=Neolithic; MLBA=Middle–Late Bronze Age; IA=Iron Age; RB=Romano-British; Sax=Saxon; med=medieval; [Neo]=within waterlogged deposits/charred deposits not associated with cereals (Godwin 1975; Hill *et al.* 2004; Stace 2010; Thomlinson & Hall 1996; Preston *et al.* 2014).
Main distribution: Eng=England; Ir=Ireland; Wa=Wales; Sc=Scotland. **K Value**: 3=Wide boreal; 4=Boreal-montaine; 5=Boreo-temperate; 6=Wide temperate; 7=Temperate; 8=Southern temperate; 9=Mediterranean Atlantic (from Hill *et al.* 2004).
Naturalized habitat (other than arable fields, waysides, urban areas): 0=No main non-anthropogenic habitats; 1=Coastal; 2=Riverine, Fen, Marsh; 3=Grassland; 4=Woodland; 5=Heath/scree; 6=Recorded as disturbed anthropogenic environment: hedges, waste ground, disturbed soils; (n)=peripheral to habitat (Hill *et al.* 2004; Grime *et al.* 1988; Stace 2010; BRC 2017).

A perhaps more pertinent question is to what extent species that entered the British Isles during the Neolithic were able to gain a foothold within what was still a greatly wooded, and spatially and temporally discontinuous, fragmented arable environment. As Jones (1988b) states, cultivated plots appear highly dispersed, forming 'a harlequin environment'. Further, between 3500 and 2800 BC environmental proxies, archaeobotanical records and radiocarbon evidence combined indicate that cereal cultivation was abandoned over much of the British Isles with the onset of rapidly deteriorating climatic conditions, with possible small enclaves of agriculture surviving in Scotland, particularly within the island communities (Fig. 2.5; Stevens & Fuller 2012; 2015). It is possible that some weeds survived within disturbed anthropogenic environments, but quite probable that many were reintroduced within the Bronze Age, and that the genetic lineages of these early introductions were no more prevalent in the succeeding Bronze Age than those of the peoples who brought them (cf. Olalde *et al*. 2017).

Even if only short-lived, the nature of Neolithic agriculture and probably the eco-systems it produced appears unique when compared to later periods. While small-seeded annual species with Type IV seed-banks are present, it appears unlikely that they were able to build up the large persistent seed-banks that characterized later agricultural fields. Likewise, the low presence of perennial species might also reflect regimes in which cultivation was relatively small-scale and intense (as per Bogaard 2005; Bogaard *et al*. 2013);
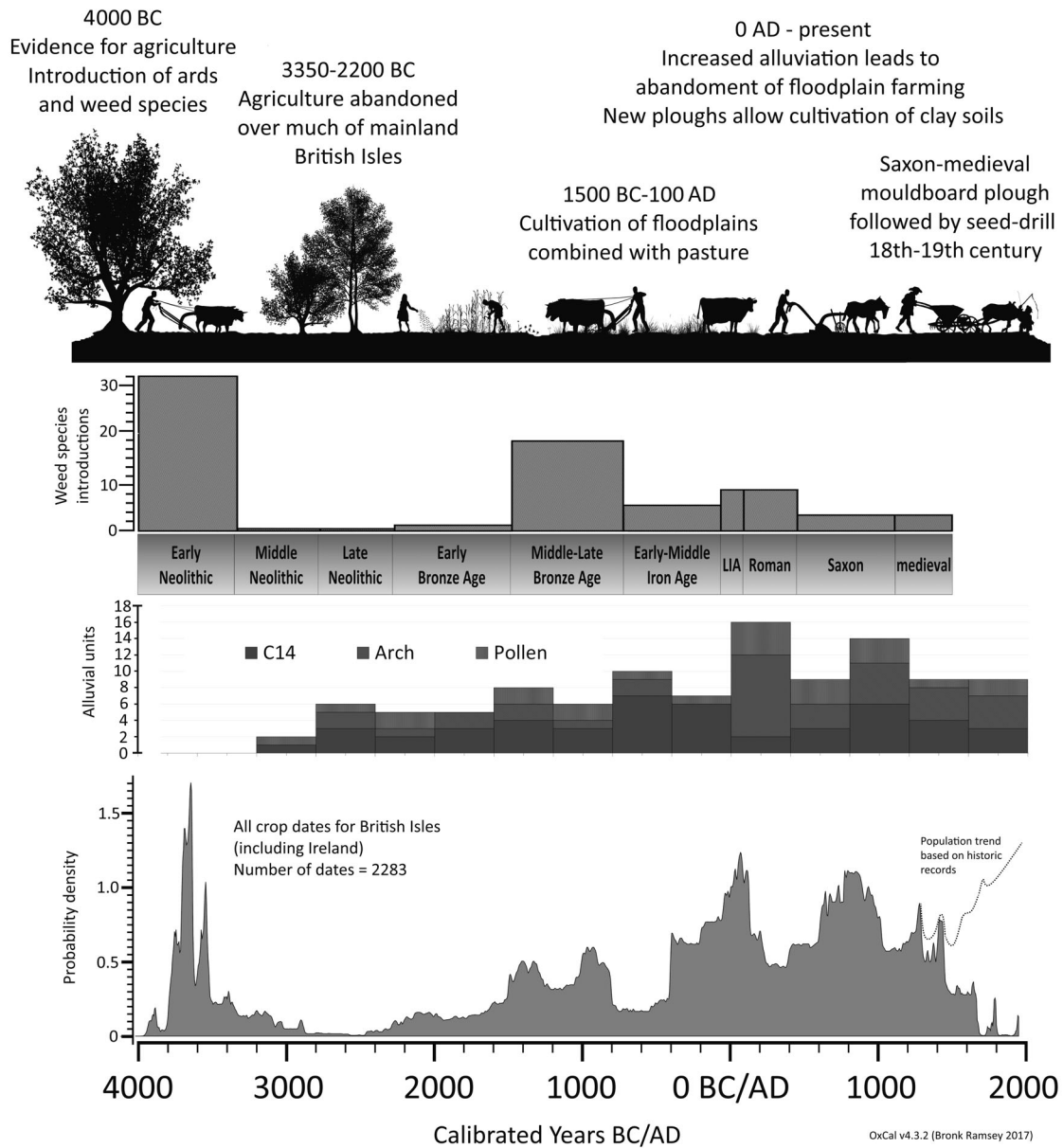
Figure 2.5. *A timeline of agricultural changes discussed in the text and number of introduced/reintroduced weed flora (from Table 2.1) plotted against evidence for increased alluviation (from Macklin & Lewin 1993) and summed probability for direct AMS radiocarbon dates on crop species (n=2283) for the British Isles, including Ireland (data taken from Bevan et al. 2017), indicating fluctuations in both agricultural activity and human population.*

2011). Given the predominance of broadcast sowing in ethnographic accounts, historical texts and pictorial evidence, the existence of intensive systems of this nature in the past without further evidence should be questioned.

Farming the floodplains: the age of the perennial weeds

The upsurge in agriculture that accompanied the Early Bronze Age, as the Beaker peoples expanded across

Europe and into the British Isles, left little archaeo-botanical record in terms of the existing weed flora of this time. Rather, as Jones (1988b) writes, it is the Middle Bronze Age that marks the birth of agricultural ecosystems within the British Isles, something that has been increasingly substantiated within recent years (Fig. 2.5; Bevan *et al.* 2017; Stevens & Fuller 2012; 2015).

Godwin (1975) saw the Romano-British period as that of the greatest increase in archaeophytes, but as more archaeobotanical data was added the emergent picture began to resemble one of more gradual change (Jones 1984). However, in the past 20 years the impression is again shifting, and now the later Bronze Age can perhaps begin to rival the Romano-British in terms of both archaeophytes and the expanding native weed flora.

The most notable foreign additions were *Lithospermum arvense,* whose rock-hard seeds could not have gone unnoticed during grinding, *Papaver rhoeas/dubium* (long-headed poppy), *Tripleurospermum inodorum* (scentless mayweed), *Malva sylvestris* (common mallow) and *Valerianella dentata*, along with possibly *Sherardia arvensis* (field madder), *Lolium perenne* (English ryegrass) and *Fumaria* sp. We might also add *Silene latifolia* (white campion), *Chenopodium polyspermum*, *Chenopodium ficifolium*, potentially small nettle (*Urtica urens*) (cf. Preston *et al*. 2004) and possibly *Vicia tetrasperma* (smooth vetch), although the first records for the latter currently appear in the Iron Age. It is notable that many of these species, including *Chenopodium polyspermum*, are low growing, and it may be that a change to bronze sickles facilitated lower harvesting on the culm, assisting their spread.

The case for the native status of *Sherardia arvensis* is still unclear. Like *Fallopia convolvulus*, there appear to be pre-Holocene records for the British Isles, and it might also be regarded as having been re-introduced (Godwin 1975). The origins of *Lithospermum arvense* probably lie in southeast Europe, and it appears in charred assemblages there by the later seventh millennium BC (Colledge & Conolly 2007; Zohary *et al.* 2012, 177–9), and later southwest Bulgaria, along with *Sherardia arvensis*, and *Valerianella dentata* at 6000–5650 BC (Marinova 2007).

Of some interest is the lack of Early Neolithic European and Near Eastern records for several of these species (Coward *et al.* 2008), most notably *Tripleurospermum inodorum*, *Sherardia arvensis* and *Papaver rhoeas/dubium*. It might be noted that *Tripleurospermum inodorum* is recorded from Neolithic Ireland (McClatchie *et al*. 2014), but this would seem out of keeping with the record for Europe. Its origins are also difficult to pinpoint, but between the Baltic coast of Europe and the Caucasus region seems most probable.

However, it is the first significant appearance of native wet ground species, such as *Ranunculus acris* (meadow buttercup), *R. repens* (creeping buttercup) and *Montia fontana* subsp. *chondrosperma* (Fenzl) Walters (blinks), commonly accompanying *Eleocharis palustris* (common spike-rush), that really distinguish the later Bronze Age and Iron Age weed flora. Bronze Age ard marks have been excavated from numerous locations, including the Upper and Lower Thames Valley (Yates 1999; 2001, table 7.3) and East Anglia (Evans *et al.* 2009), indicating an expansion of the agricultural landscape that incorporated river floodplains (Fig. 2.5).

It is with this evidence that the early work of Martin Jones on *Eleocharis palustris* should be considered (Jones 1981; 1984; 1988a,b). *Eleocharis palustris* is a native British species, occupying wetland habitats on the margins of water bodies such as rivers, streams and ponds. Today, floodplains are not seen as conducive to arable agriculture, and the case for *Eleocharis* being a past arable weed rested upon its unequivocal association with cereal remains, seen through its presence within storage contexts associated with charred grain, as well as the stomach contents of bog-bodies (Jones 1988a,b). As Jones writes, *Eleocharis*, while not associated with wheat crops today, is found within dry-sown rice paddies, demonstrating that it can survive a fair degree of disturbance and drying out of the soil, as might have existed within poorly drained prehistoric fields (Jones 1988a).

The presence of *Eleocharis* as a weed of arable fields is likely down to three important factors. The first is the nature of its reproduction. It can survive a drop in water-table during summer below soil level, but most importantly, while little reproduction through seed takes place, reproduction by rhizome within the second year of growth occurs when old rhizomes break away from the adult plant (Walters 1949), as might occur under arding. It also frequently co-occurs today in wet-marshy rough pastures alongside *Lolium perenne, Poa, Trifolium, Cirsium, Ranunculus acris* and *Rumex* sp., whose charred seeds are commonly encountered in archaeobotanical samples of this date, making their first real appearance in the arable weed flora (see Table 2.1).

This brings us to our second point, that the high numbers of predominantly grassland perennials which dominate later Bronze Age and Iron Age samples might indicate a changing attitude to land use. While high numbers of perennials can be associated with low-disturbance tillage by ard, they are also correlated with the cultivation of fields previously under pasture (Chancellor 1985; 1986). The use of Bronze Age fields for arable can be seen from ard-marks, but it seems probable that a pattern of land use emerged

within this period in which such fields regularly alternated between animal pasture and arable (Figs. 2.3, 2.5).

The third point is the changing nature of the floodplain itself. Today, floodplains are heavily alluviated, but the onset of such anthropogenic alluviation is generally only dated to the start of the Bronze Age, increasing in later periods (cf. Fig. 2.5; Macklin *et al.* 2014). In the Upper and Lower Thames Basin, around a metre of alluvium was deposited within the Romano-British period alone, with increasing amounts in the Late Saxon and medieval period (Robinson 1992; Stevens *et al.* 2012, 404–7). This led to the poorly draining alluvial soils of today, which rendered the floodplain largely uncultivable. But in the Bronze Age and Iron Age, while fields might be inundated with autumn and winter floodwaters, it is likely they had sufficiently drained away by spring to enable roots to breathe.

Such evidence is by no means unique to the British Isles and is also seen in the Netherlands from the Early Bronze Age onwards (Arnoldussen 2008, 257–9). Further similar weed assemblages, including *Eleocharis palustris*, have been recovered as far away as the Carpathians in Hungary during the Late Neolithic, 4700–4300 BC (Gyulai 2007), as well as Iron Age Europe (Kruez & Schäfer 2011).

New invasions, new innovations

The Roman invasions of England from Caesar's campaigns of 55 and 54 BC to Claudius' conquest in AD 43, and the shifting nature of Europe within the closing centuries of the first millennium BC, brought about many changes within the agricultural landscape of England, not to mention a whole new suite of weeds previously unknown to the farmers of Albion.

Such changes appear to have manifested themselves in one of two ways: the first through the increased geographical movement of peoples, and crops and weeds, through trade, taxes and migration; the second through a shift in agricultural innovations, particularly tillage technology, and an expansion onto new soils.

Among the new debutants is corncockle (*Agrostemma githago*) which, as noted above, probably originates in the mountains of Greece, where it is present from the earliest Neolithic (Coward *et al.* 2008). The earliest records for this species in the British Isles come from the Late Iron Age (Evans & Jones 1979; Lodwick 2014), but it becomes increasingly recurrent during this period. The association of both *Agrostemma githago* and probably *Centaurea cyanus* (cornflower) with Roman expansion is seen within northern France, where it is attributed to the importation of grain (Derreumaux & Lepetz 2008). Also included is *Lithospermum arvense*, a species hitherto absent in northern France (cf. Bakels 1999), yet present in Britain since the later Bronze Age.

Of greater importance is the occurrence of *Anthemis cotula* (stinking chamomile), a noxious species associated particularly with the cultivation of heavier clay soils. Seeds of this species, together with *Agrostemma githago*, have been recorded from earlier contexts (cf. Preston *et al.* 2004); however, experience tells us that such finds often occur from sites with overlying medieval components (see Stevens & Fuller 2012) and hence are probably intrusive. Indeed, where direct radiocarbon dating has been carried out this has proved to be the case (Pelling *et al.* 2015). Seeds of *Chrysanthemum segetum* (corn daisy) are also known from Iron Age contexts, but that they appear more commonly in Romano-British contexts suggests a Late Iron Age to Romano-British introduction. This species, in contrast to *Anthemis cotula*, is characteristic of lighter, sandier, acidic soils, and taken together they indicate an expansion of arable practice during this period.

The interpretation of the changes within the Iron Age through the Romano-British period by Jones (1981; 1984; 1988a,b) drew together several key elements: the appearance of free-threshing wheat, improvements in ploughing technology, the decline of *Eleocharis palustris, Carex* spp. and *Montia fontana* subsp. *chondrosperma,* and the rise of *Anthemis cotula,* a noxious species associated particularly with the cultivation of heavier clay soils. The logical inference chain presented the argument that improved ploughing technologies allowed the cultivation of heavier soils, such as on alluvial plains. On these ploughed heavier soils, free-threshing wheats were increasingly grown. Consequently, the improved drainage of the floodplains eventually led on to the decline in wetland species.

We would now suggest that some modification of this argument is necessary. While Jones very much saw a continuum of change beginning in the Middle to Late Iron Age and continuing through the Romano-British period, he took into account no likely problems of intrusive material. On recent reconsideration of these problems, a different picture emerges. While bread-wheat has been shown to be present within Iron Age Britain, many finds have proved intrusive, as is likely with some of the weeds that accompany them (Pelling *et al.* 2015; Stevens & Fuller 2012). It now appears that bread-wheat played a substantial role in neither Iron Age nor Roman agriculture within the British Isles. The rise in *Anthemis*

cotula undoubtedly can be related to the expansion of agriculture onto clay soils, and the introduction of asymmetrical shares, seen through finds of iron coulters, the cutting implement that cuts the sod before the wooden share, which lifts and turns it. But it is likely such practices were at first restricted to more Romanized settlements within the first century AD, only becoming more commonplace within the third and fourth centuries AD.

This expansion onto clay soils no doubt contributed to the rise of clay alluvium on the floodplains, with increased run-off from clay soils under cultivation taking it into the river catchment areas where it accumulated (Stevens *et al*. 2012, 405–7). The decline of both *Eleocharis* and *Montia* might then be in part due to the eventual abandonment of such areas for cultivation during the later Roman period (Fig. 2.5; cf. Robinson 1992). It might also be noted that both species are commoner on lighter soils that allow their roots to breathe and would be diminished by clay alluviation.

The battle won and lost

Many of the associations made by Jones (1981; 1984; 1988a,b) for the Late Iron Age to the Romano-British period gain more prominence within the Saxon and Medieval periods. The weeds that made their first appearance in the Romano-British period, *Anthemis cotula*, *Agrostemma githago*, *Centaurea cyanus*, *Chrysanthemum segetum*, become mainstays of charred assemblages within the Medieval and Saxon period (cf. Jones 1988b). There is also a notable transition to a much greater dominance of annual weed seeds with persistent seed-banks and away from perennial species (Fig. 2.4) that has been linked to the appearance and spread of mouldboard ploughs from the seventh to eighth centuries AD (cf. Stevens & Robinson 2004; Thomas *et al*. 2016).

The Saxon to Medieval period in many ways sees the changes discussed by Jones (1981; 1988a,b; 2009) that were occurring in the weed flora over the Romano-British period come to fruition. Spelt wheat is replaced by bread-wheat and, gradually over much of Saxon England, the ard by the mouldboard plough (Fig. 2.5).

One curious phenomenon is the increased appearance of *Lapsana communis* (common nipplewort) in charred assemblages from the Saxon to medieval period. The species is one of the key defining weeds of the Neolithic *Bandkeramik* of Europe (Bakels 1999; Knörzer 1971) and present in waterlogged assemblages from the Neolithic onwards (e.g. Nye & Scaife 1998; Robinson 1989; Tomlinson & Hall 1996),

but regarded as doubtfully native (see Preston *et al*. 2004). Yet in Britain its first occurrence charred is in the Late Romano-British to Saxon period (Greig 1990; Stevens & Robinson 2004). Why this species appears to have taken so long to become established as a weed in the British Isles is unknown, but in part, may be its greater tolerance to heavier clay soils (Salisbury 1961, 294).

By the sixteenth century, darnel (*Lolium temulentum*) had gained a reputation as one of the worst weeds within England, and shared a similar status, according to Virgil, within Mediterranean fields some millennium and a half before (Salisbury 1961, 30). Yet there are few records for the British Isles prior to the Medieval period. The species appears to have originated through evolution in early cultivated fields of the Levant by *c*. 7000 BC, based on divergence of *L. remotum/L. persicum* (see Fuller & Stevens, this volume).

While the angled shares of the mouldboard plough did much to eliminate many of the perennials that once plagued prehistoric farmers' fields, other developments since the start of the British agricultural revolution, spanning the last four centuries, served to reshape the composition of the arable weed flora. Such inventions, including improved harrows, first depicted in the Bayeux Tapestry (*c*. AD 1070), would have further diminished many perennial species and those of seed-bank Types I–III. The Mesopotamian seed-ard apart (Hillman 1984), the history of the dibbler to plant seeds in a row dates back to the fifteenth century in Italy. The advantage of such methods was first that grains were individually 'hand-loaded', usually in batches of four to five, eliminating many grain-sized weed seeds with Type I seed banks. Also, planting within rows allowed more efficient weeding to be conducted within the early growing stages, a development that, although improved upon by the invention of the seed drill by Jethro Tull in 1701, was not widely adopted until the nineteenth century (Fig. 2.5). The adoption of these planting methods, accompanied by the use of mechanical screens to remove grain-sized contaminants from the crop, gradually eliminated many of the grain-sized weed seeds including those of seed-bank Types II and III. It was these practices that did much to remove many common weeds, such as darnel, corn marigold, cornflower, corncockle, pheasant's eye and cleavers. However, as Salisbury (1961) writes, it was not until the 1950s with the use of herbicides that the battle was at last decided. What the agriculturalist won, the botanists lost, and today's cornfields are no longer the picture of colours which once adorned the landscape every summer for the past four millennia.

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