Weed Seed Biology

A ramble down memory lane

Bob Froud-Williams

Factors that compromise reduction of weed seedbank

- Vast reserves of seeds in soil seedbank
- Intensity and frequency of soil cultivation
- Somatic and genetic regulation of dormancy
- Seed polymorphisms that require different stimuli to alleviate dormancy

Constraints to Weed Seed Eradication

- Fecundity
- Dormancy
- Longevity

- When do they germinate?
- How long can they survive?

Periodicity of Germination

- Germination indifferent to Season
- Bimodal germination in autumn and spring
- Germination entirely in Spring
- Germination mostly in autumn

Periodicity of Germination

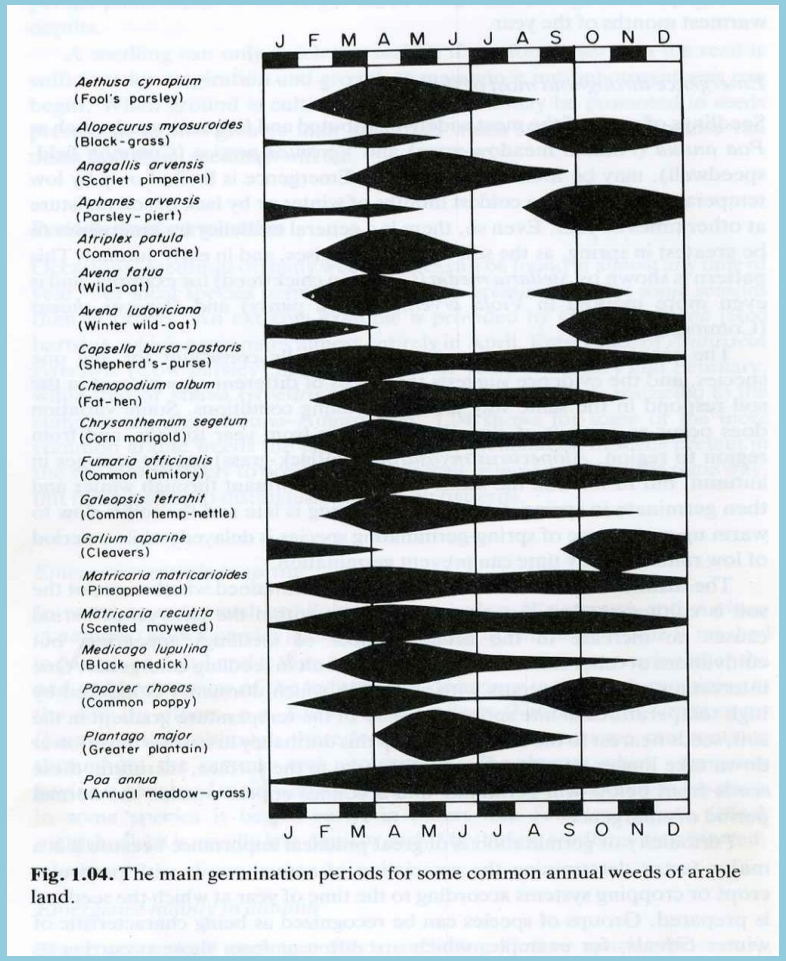
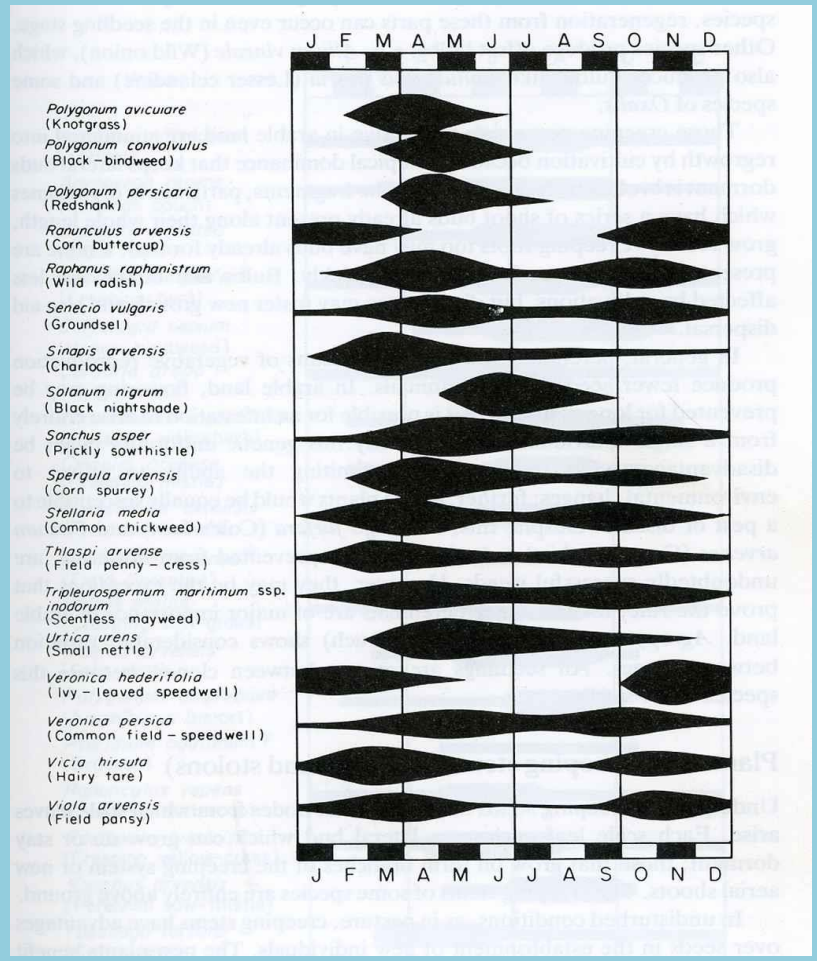


Fig. 1.04. The main germination periods for some common annual weeds of arable land.

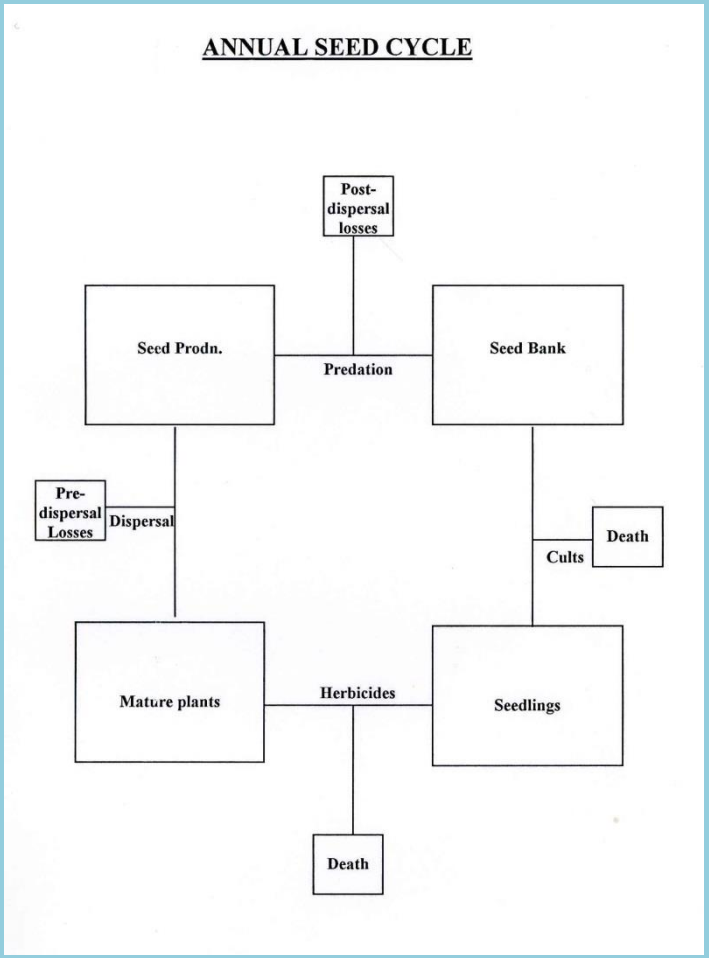


Safe-sites

- Stimuli required for alleviation of dormancy
- Favourable conditions for germination
- Resources consumed during germination
- Free of specific hazards

Life history cycle and population dynamics

- Seed production
- Seed rain
- Seed bank
- Seedling recruitment
- Establishment



Weed population dynamics

Intermediate phases

- Seed production
- Seed rain
- Seedbank
- Seedling recruitment
- Establishment

Interphase

Seed multiplication

Dispersal losses

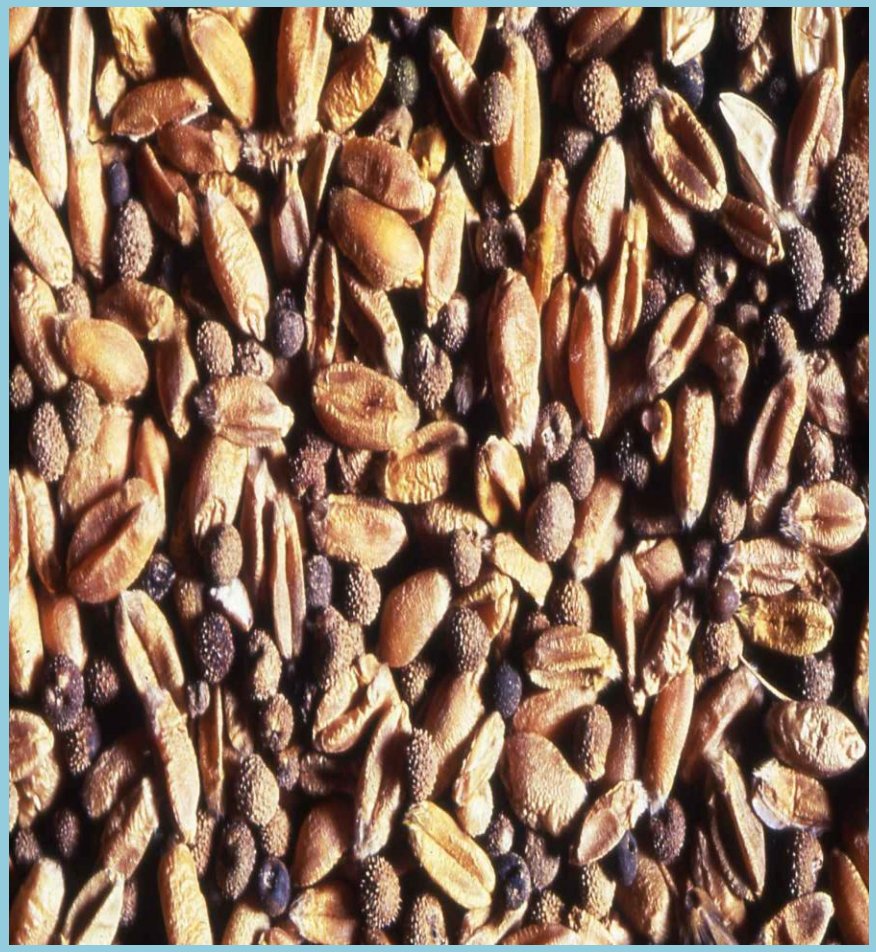
Fate of seeds on soil surface

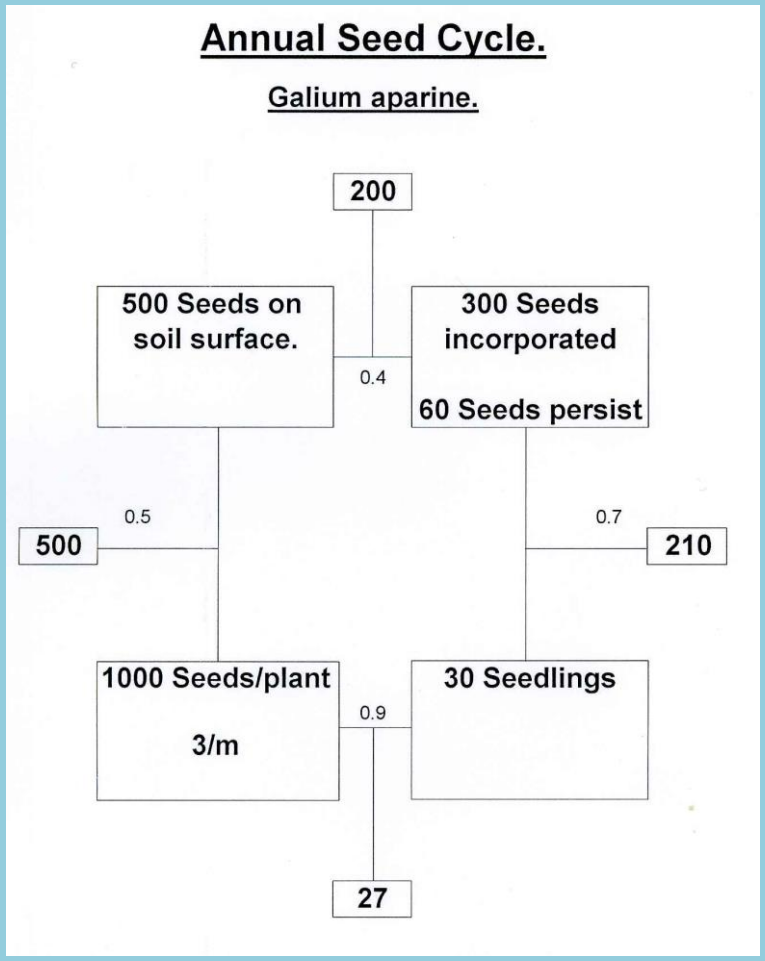
Germination/Emergence

Post-emergence fate

After Sagar and Mortimer, 1976

Annual seed cycle of *Galium aparine*

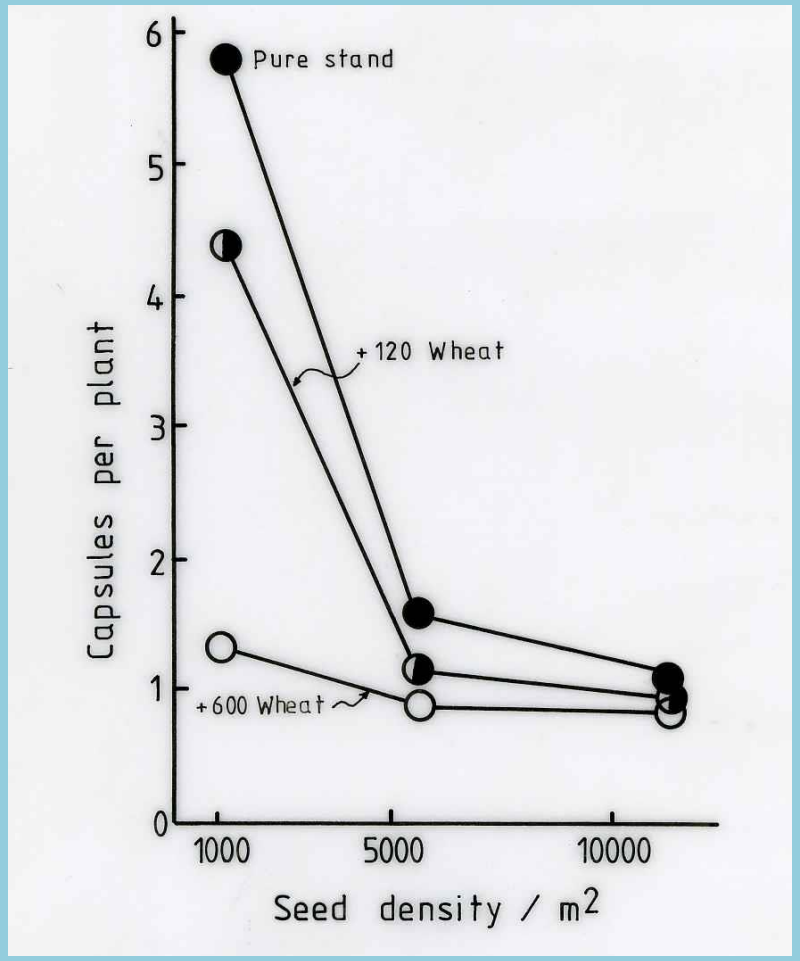


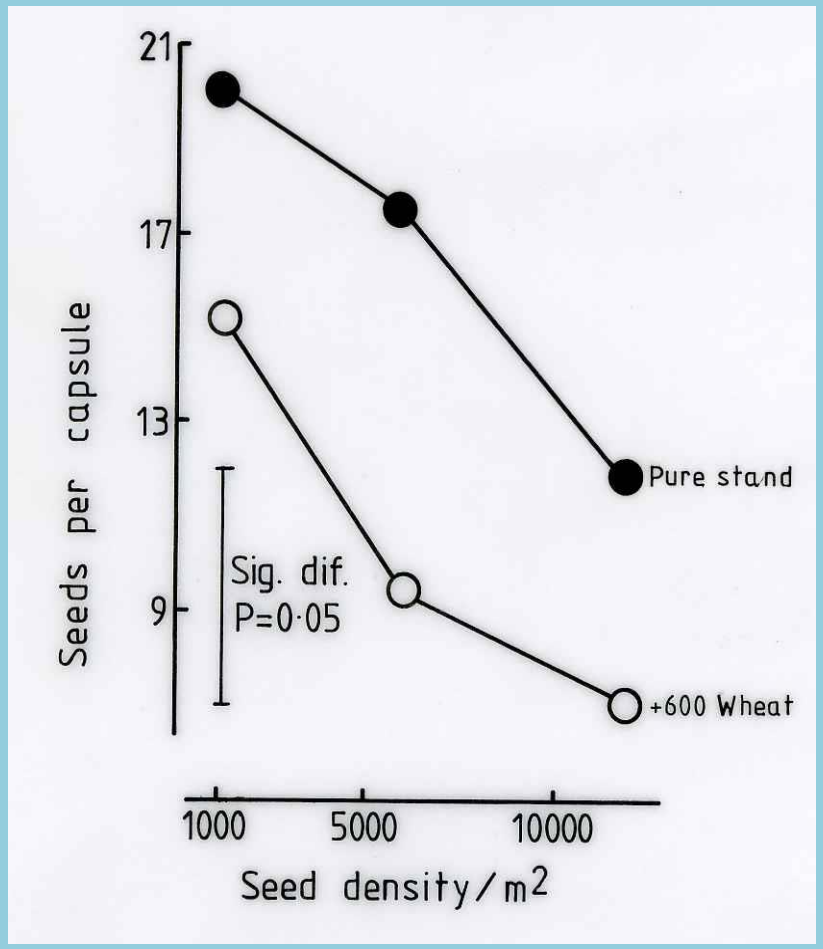


Reproductive output as number seeds per plant and seed weight (mg)

Papaver rhoeas	20,000	0.09
Matricaria perforata	15,000	0.29
Stellaria media	15,000	0.35
Viola arvensis	2,500	0.40
Veronica persica	c.100	0.52
Lamium purpureum	600	0.90
Polygonum aviculare	c.200	1.45
Galium aparine	400	7.25
Bromus sterilis	>200	8.37

The relationship between number of capsules/plant and seeds/capsule of *Agrostemma githago* in pure stand and in mixture with w.wheat at various seed densities





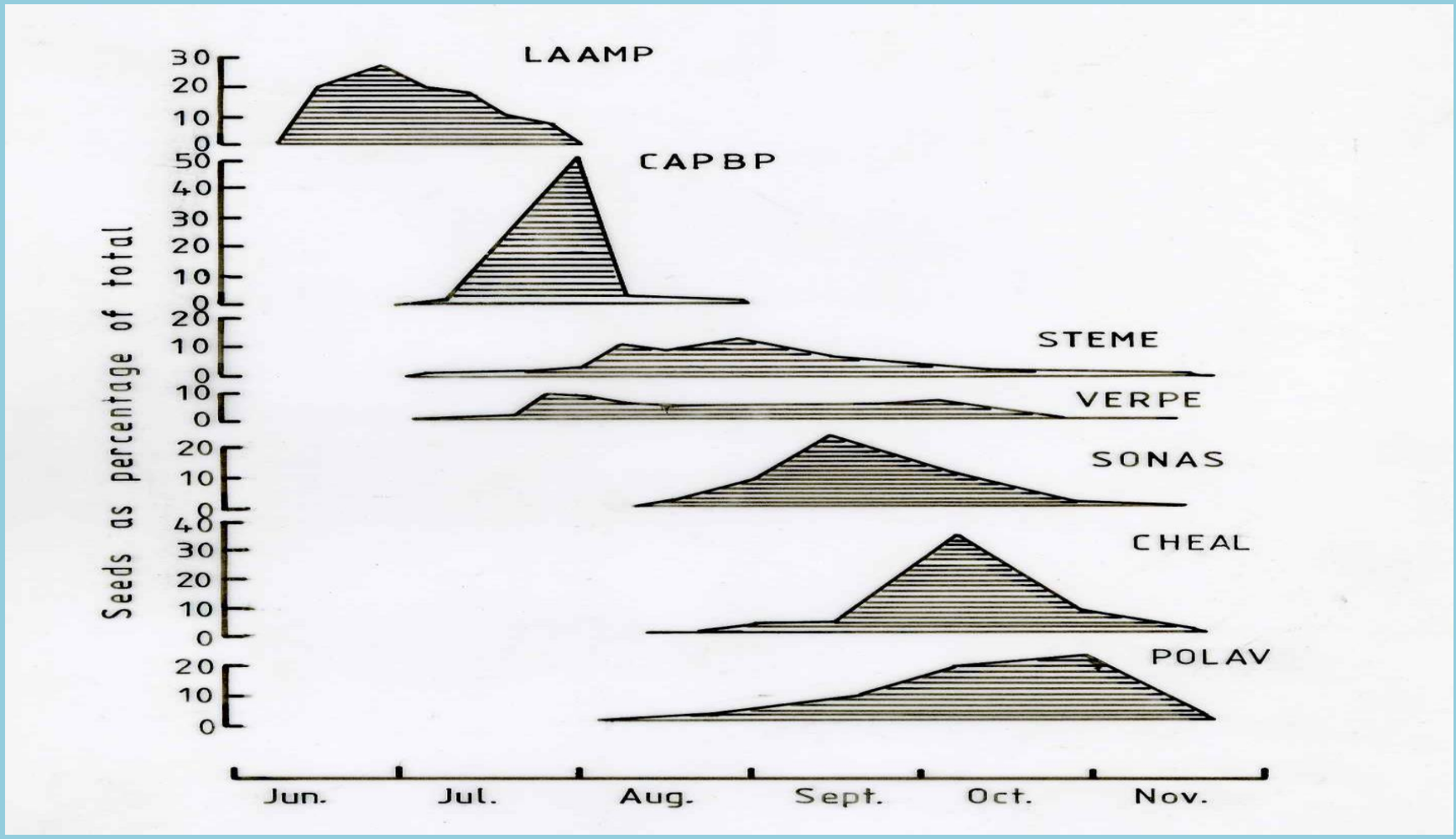
after Harper & Gajic, 1961

Effect of crop density (plants m^{-2}) on seed production per plant

	0	40	114	206
Lamium purpureum	27634	4594	2022	1075
Viola arvensis	8944	967	562	354
Papaver rhoeas	531273	41059	12442	6221

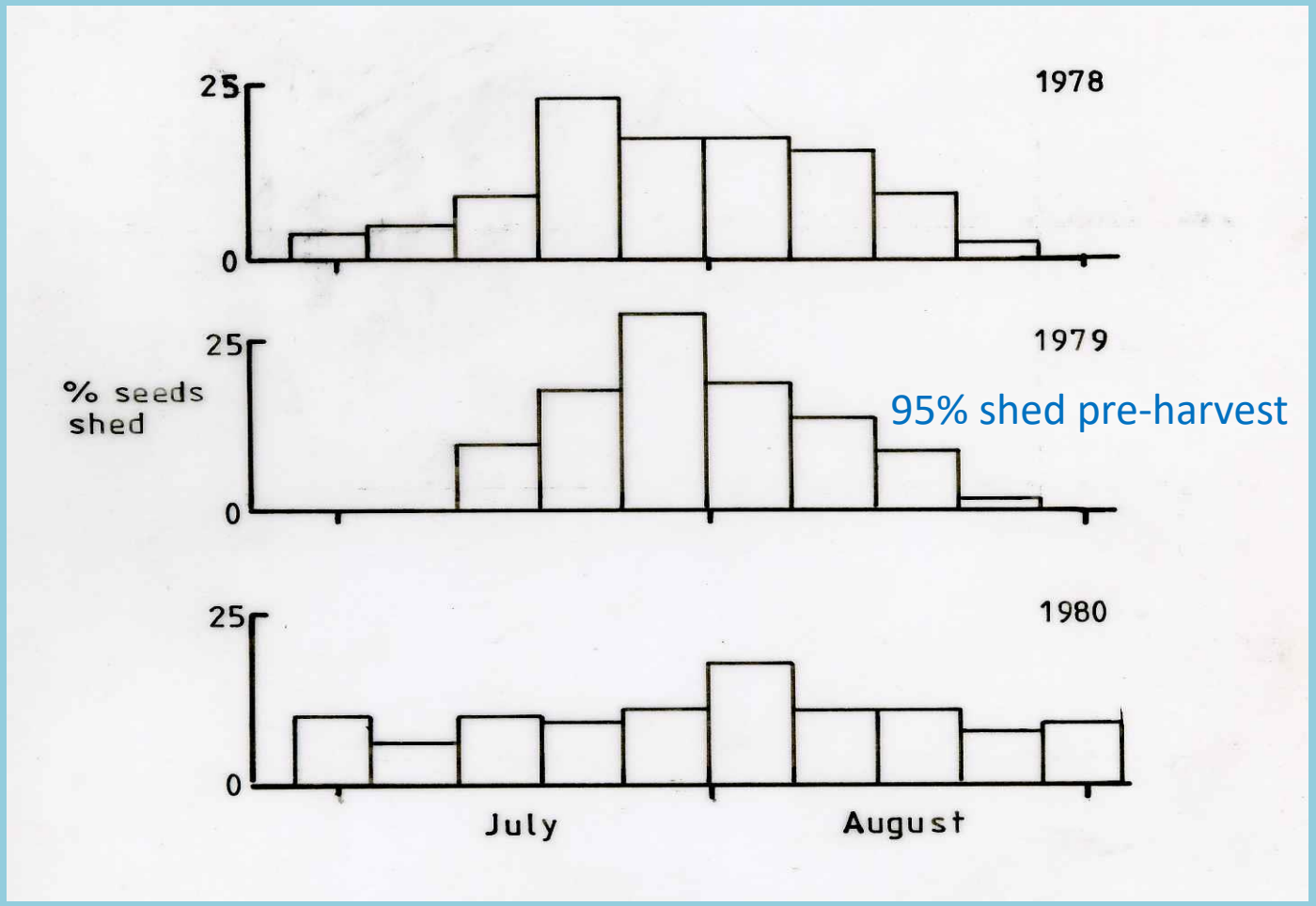
after Wilson *et al*.,1995

Seed rain patterns of selected weed species



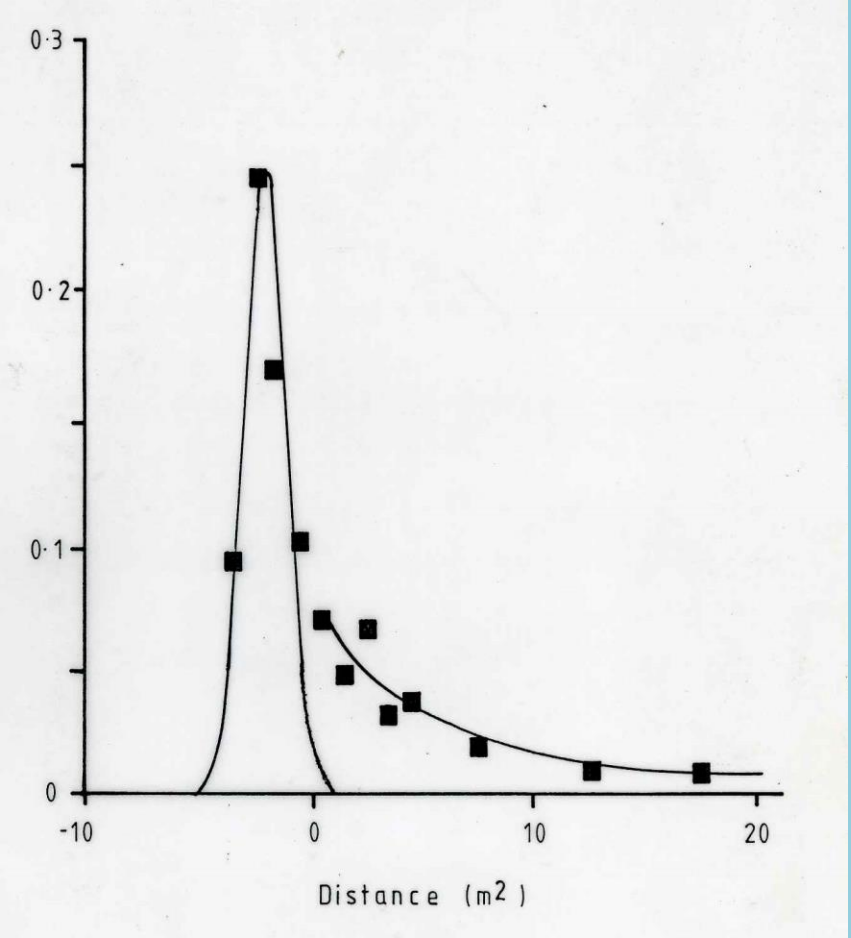
after Leguizamon & Roberts,1982

Seed rain pattern of *Alopecurus myosuroides* in w.wheat in three successive seasons



after Moss, 1983

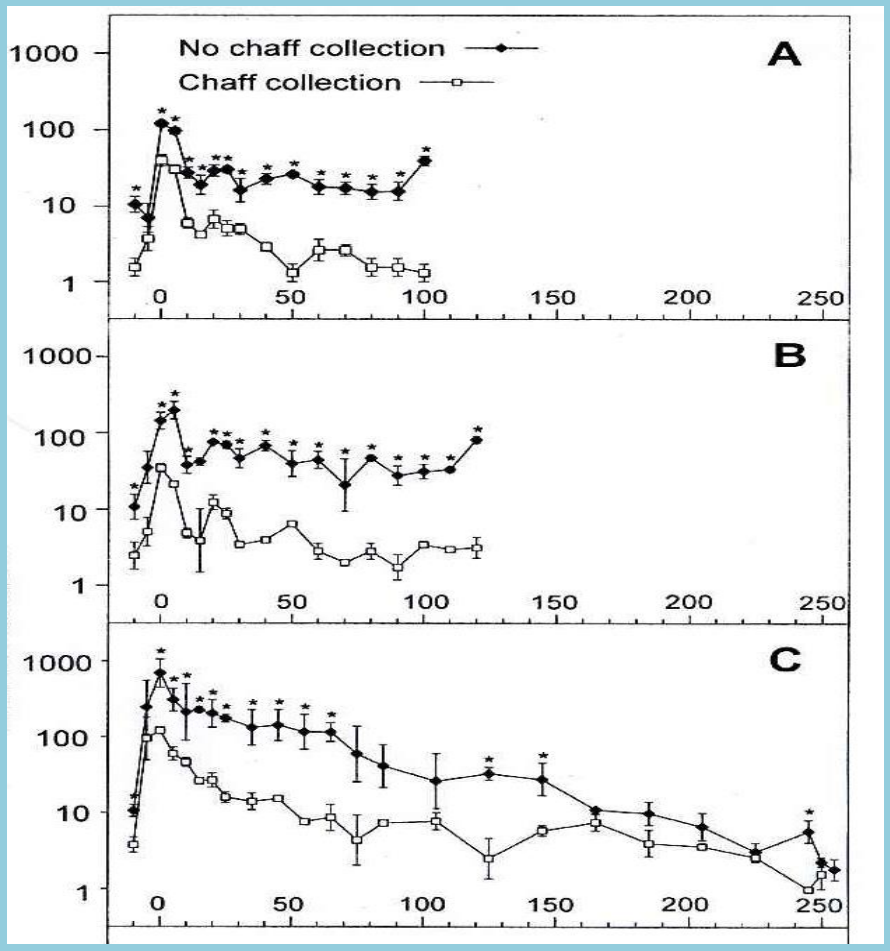
Dispersal of *Bromus sterilis* by combine harvester



- Deposition at a modal distance of 3m behind
- Forward movement of harvester slower than plant material within
- Some seed discharged forward of the point of intake up to 20m distant

after Howard *et al.*, 1993

Seed dispersal and the combine harvester

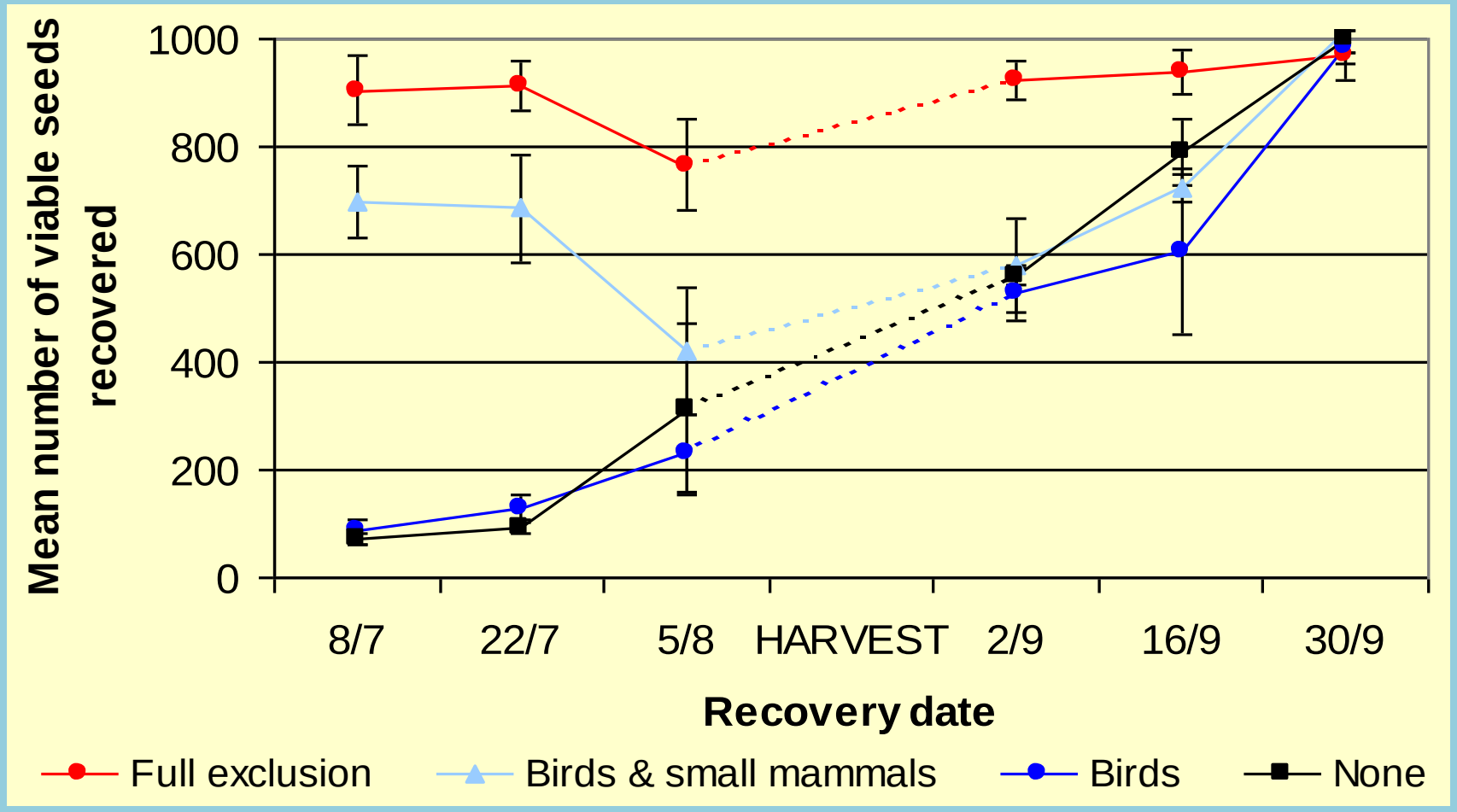


- Chaff collection reduced amount and distance that wild oats were dispersed.
- More than 74% of total wild oats ejected from combine in chaff.
- Chaff collection reduced wild oat dispersal to <10 seeds m^{-2} at 45m from source in comparison with >10 seeds m^{-2} up to 145m beyond source

Distance beyond source m

After Shirtliffe & Entz (2005)

Effect of seasonal predation on seeds of *Polygonum aviculare*



after Maucheline *et al.*,2005

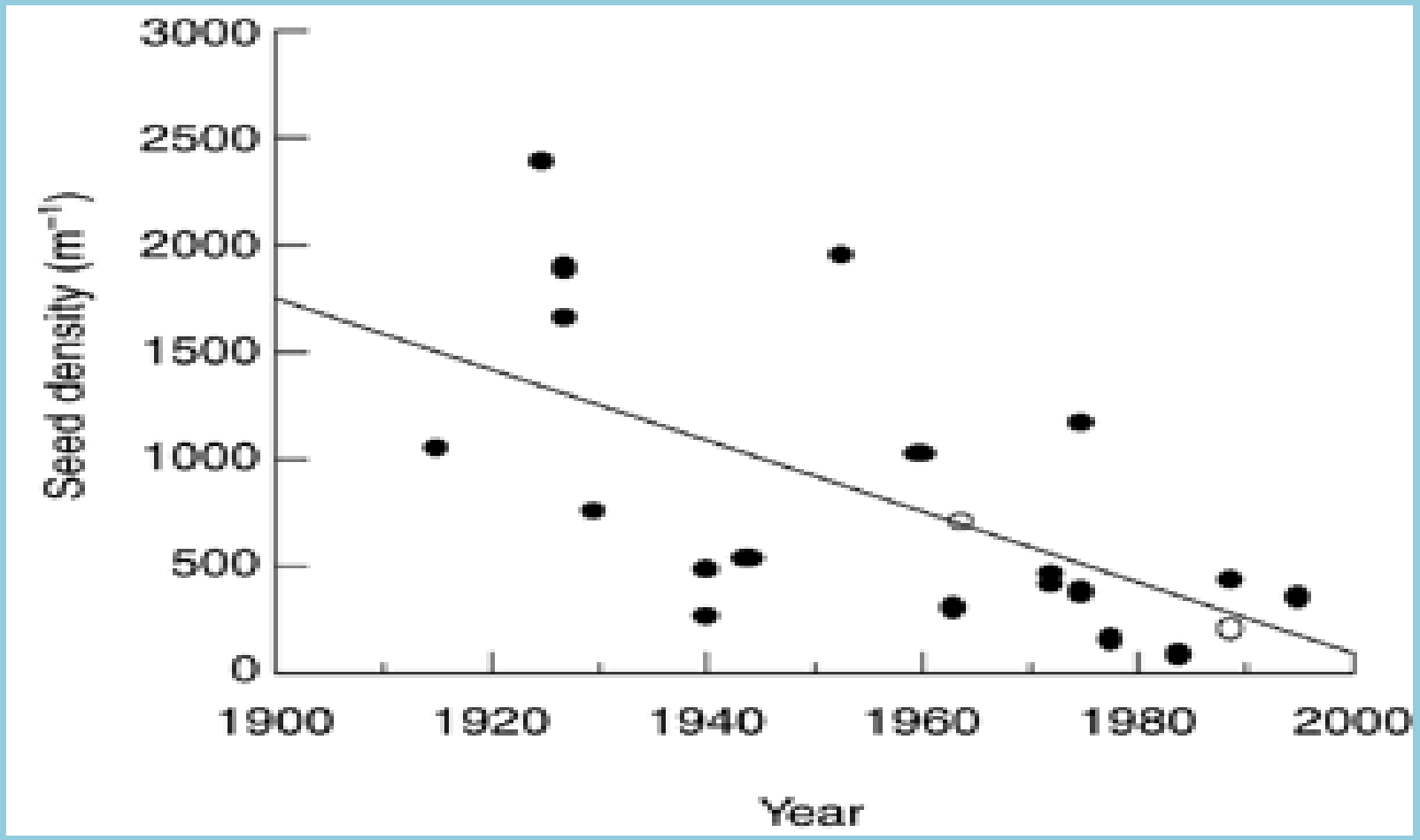
Seedbank Dynamics

- What prevents germination premature to incorporation in the soil seedbank?
- How are seeds incorporated?
- What factors facilitates re-exhumation?
- Once incorporated what factors regulate their survival and subsequent establishment?

Size of seedbank

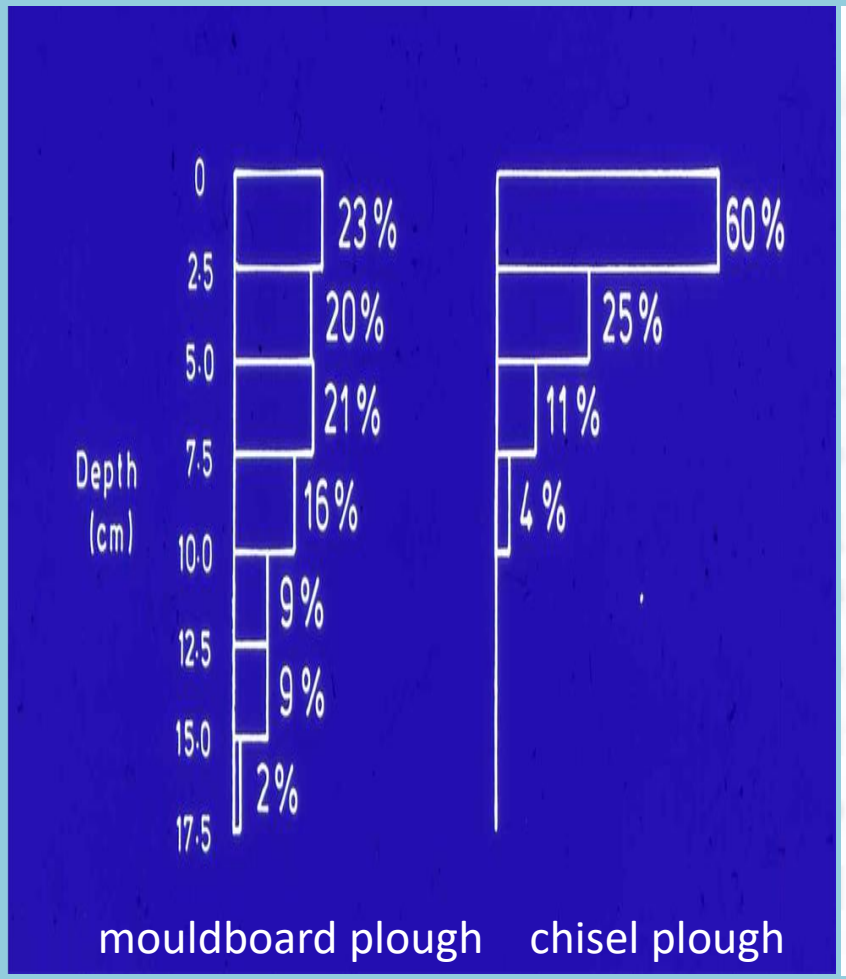
Seeds m^{-2}	Authority
30-80,000	Brenchley & Warington, 1930
4900-57,500	Jensen, 1969
1600-86000	Roberts & Stokes,1966
1500-67,000	Roberts & Chancellor,1986

Changing status of arable seedbanks

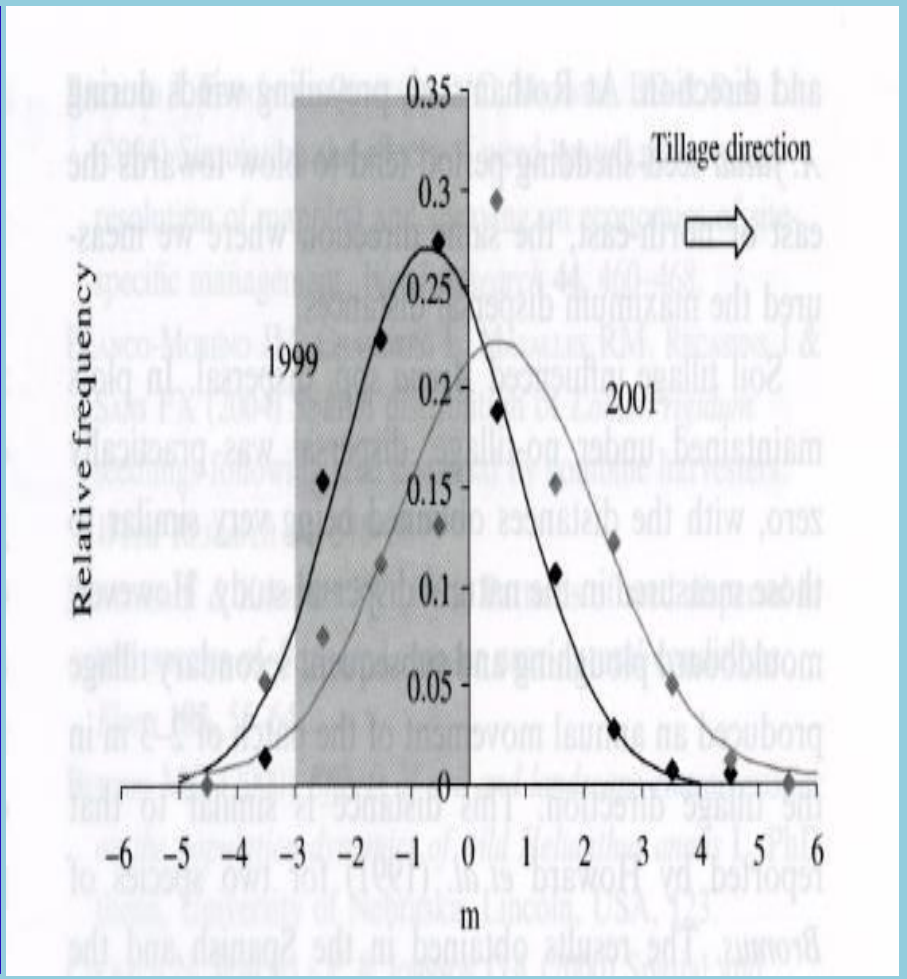


after Robinson & Sutherland'02

Effect of tillage on vertical and horizontal distribution of *Avena fatua* seed in soil

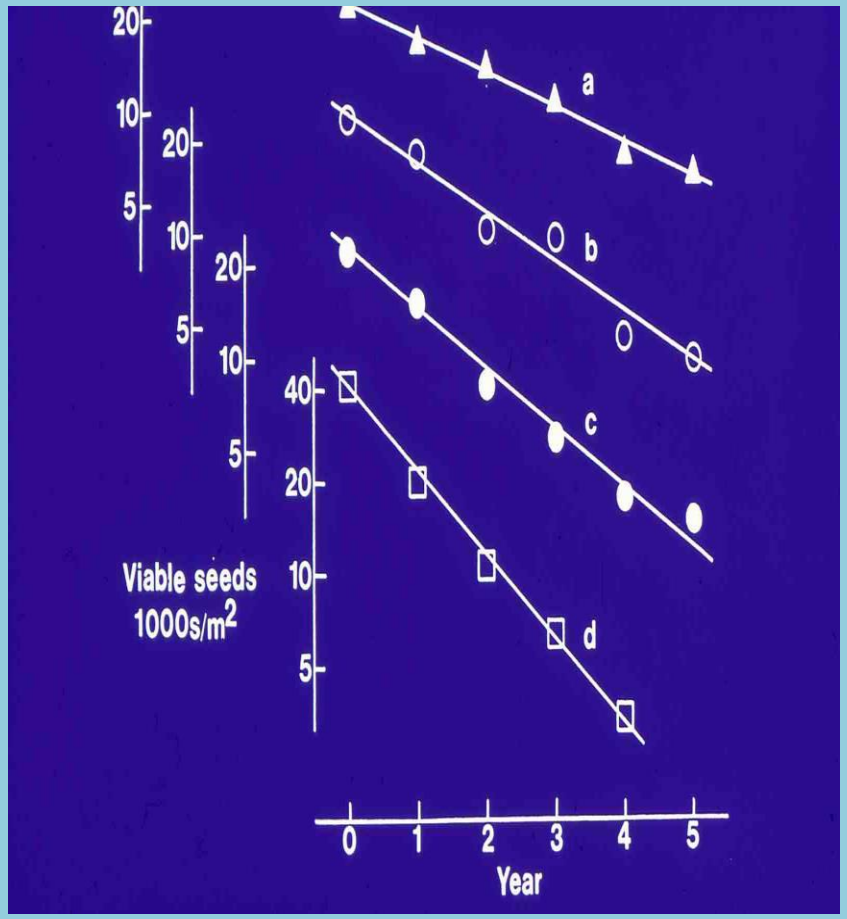


after Fay & Olson,1978



after Barroso *et al.*, 2006

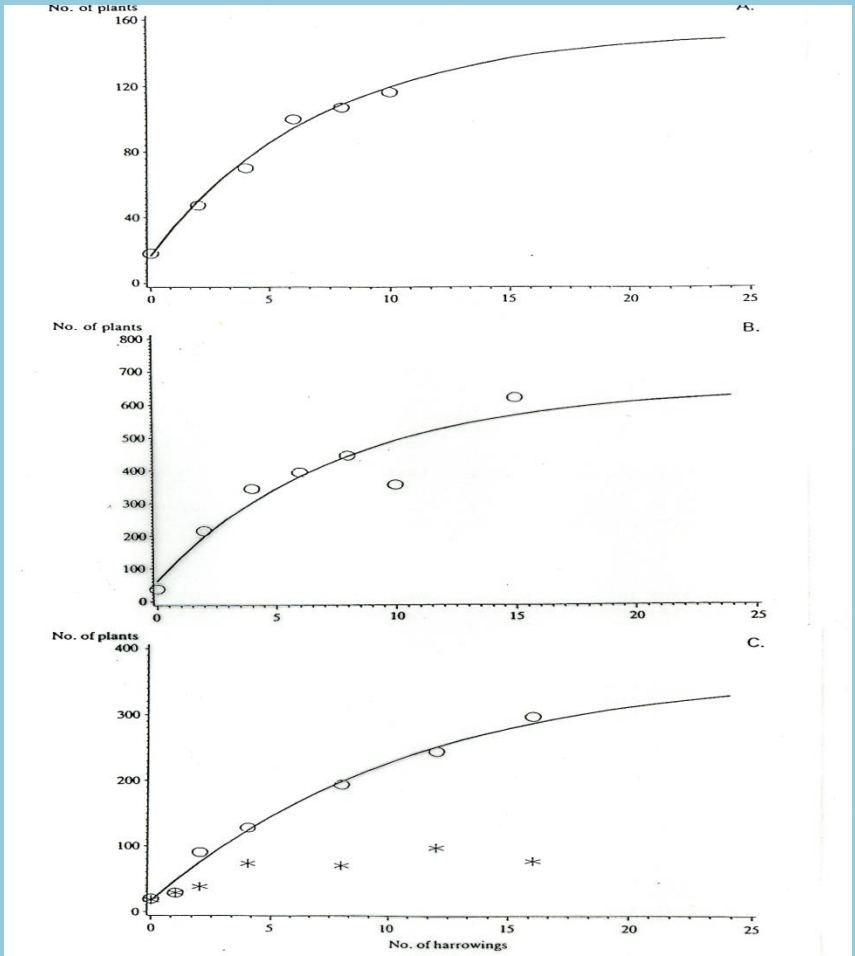
Seed Decline



- a. undisturbed soil
- b. cultivated twice per year
- c. cultivated four times
- d. cultivations in vegetable crop sequence

after Roberts, 1970

Relationship between number of harrowings in daylight and *Chenopodium album* emergence m^{-2} (observed values and predicted curve)*dark treatment.



- Exponential relationship between harrowing intensity (0-16 passes) and *C.album* emergence
- Daytime harrowing stimulate c.50% germn. after 4-7 passes,whereas in dark no further germn.after 4 passes
- Seedlings emerge from greater depth following cultivation in light

after Jensen,1995

Longevity of seeds in cultivated and undisturbed soil

	undisturbed	cultivated
% mean seed decline annum^{-1}	12	32
range	6-21	20-26
		44-48
% viable seed after 6 years	27.5	5.9

after Roberts & Feast,1972

Emergence and survival of seeds sown at different depths in cultivated and undisturbed soil

Depth (cm)	undisturbed	cultivated
2.5	58 (6.8)	75 (2.3)
7.5	36 (16.5)	65 (4.0)
15.0	21 (31.6)	54 (7.7)

after Roberts & Feast, 1972

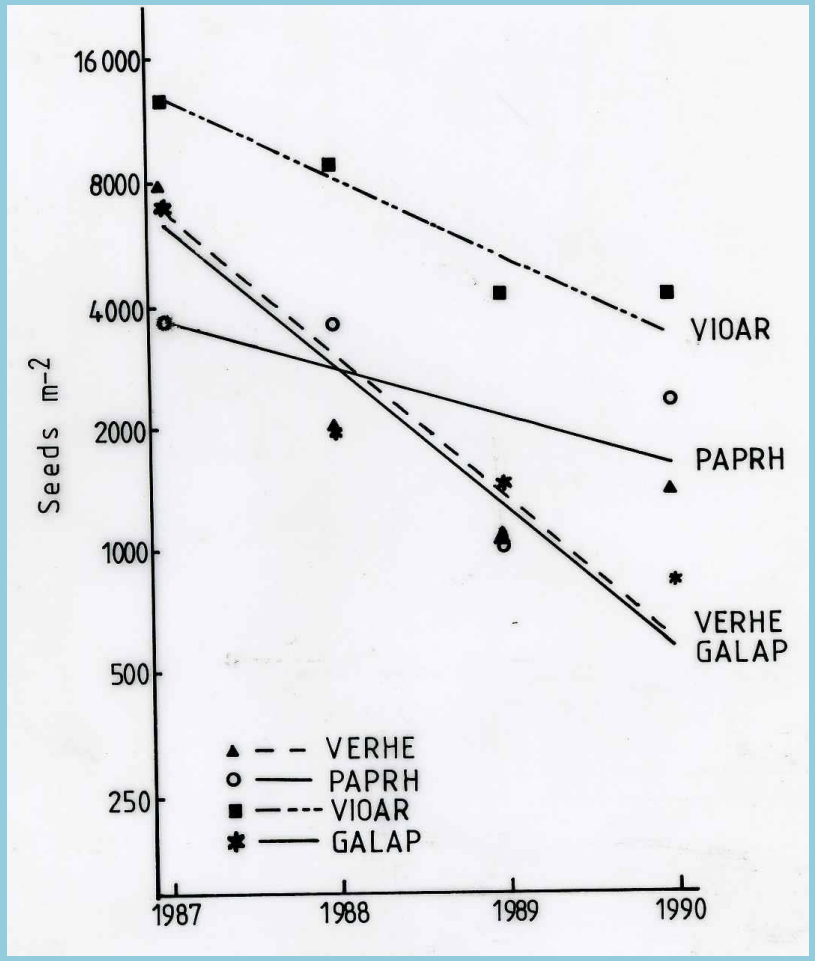
% seed survival after six year burial

	Undisturbed	Cultivated
Chenopodium album	53	9
Polygonum aviculare	39	8
Viola arvensis	38	7
Veronica hederifolia	35	1
Fumaria officinalis	31	10
Matricaria perforata	23	10
Stellaria media	22	4
Papaver rhoeas	21	7

after Roberts & Feast,1973

Annual seed decline of various arable weeds (%)

- *Papaver rhoeas* 35
- *Viola arvensis* 36
- *Veronica hederifolia* 57
- *Galium aparine* 66

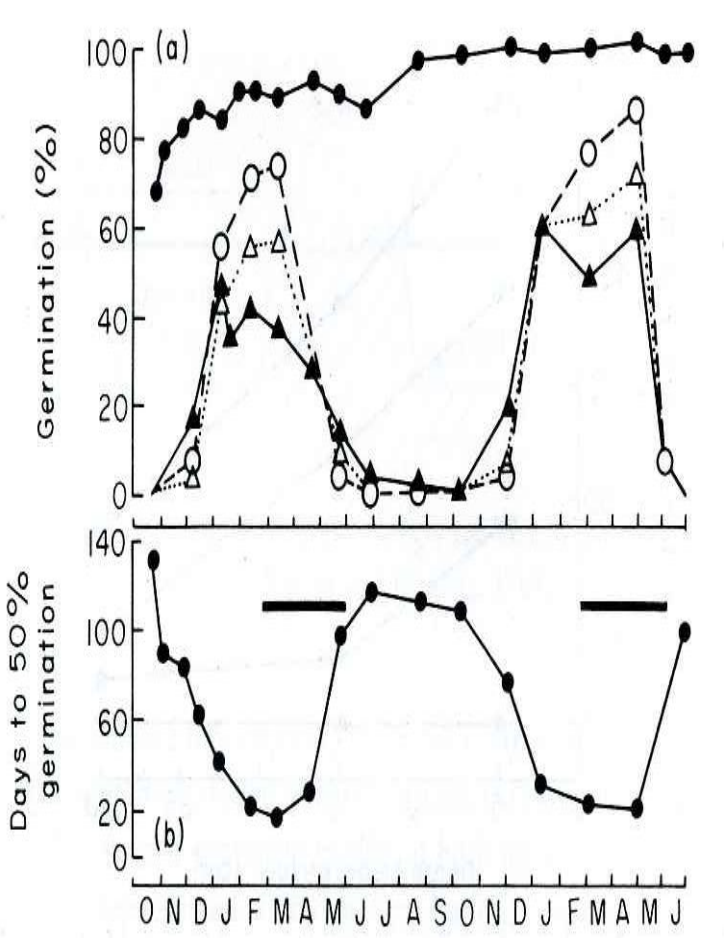


after Wilson & Lawson, 1992

Seed Dormancy

- Innate
- Induced
- Enforced

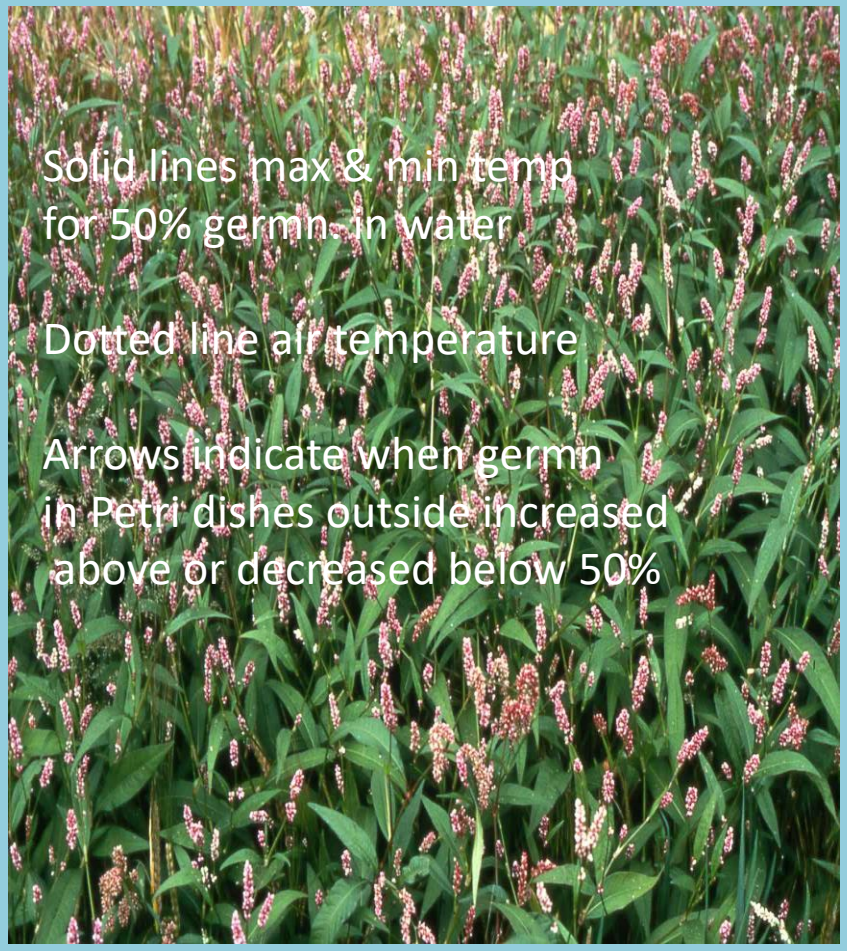
Cyclic changes in dormancy

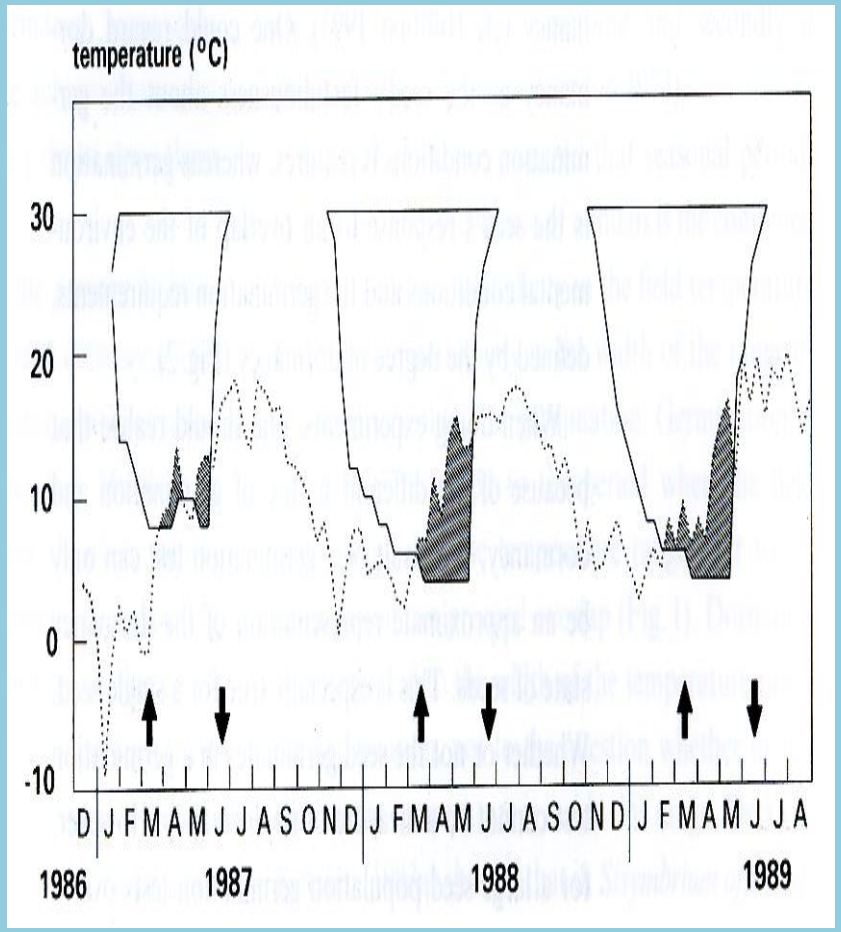


- (a) % germination of *Polygonum aviculare* at 4ºC ●,8ºC ○,12ºC Δ and at 23ºC Δ when recovered from the field at various times of year
- (b) number of days for 50% germn. at 4ºC
- Horizontal bars denote field emergence

after Courtney,1968

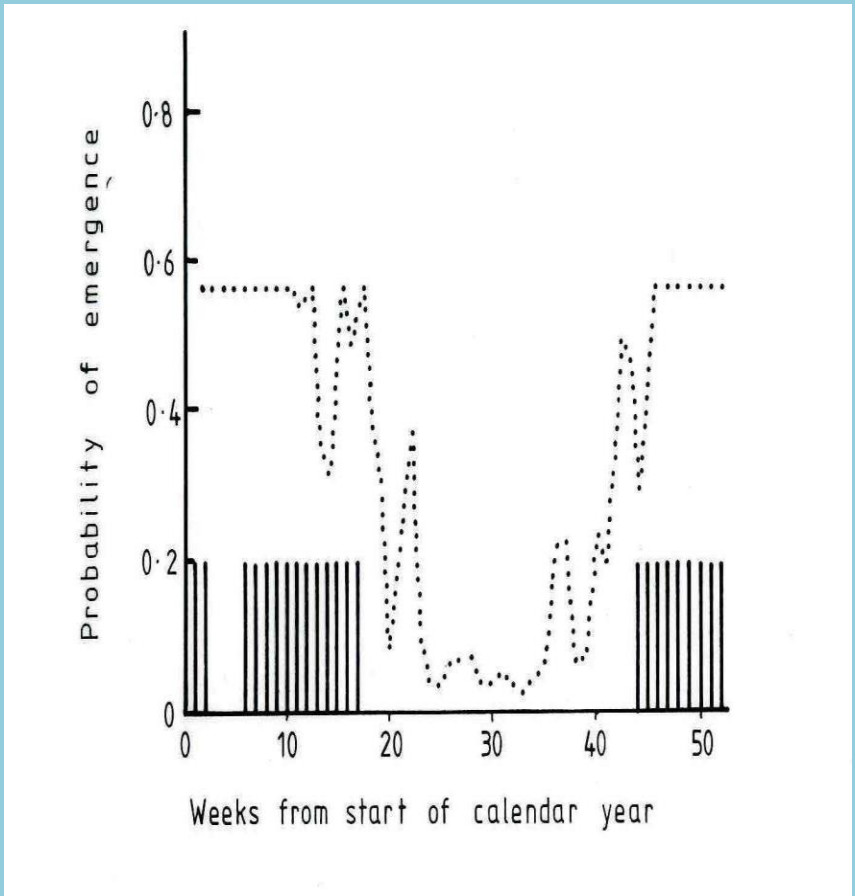
Simulated seasonal changes in the range of temperatures at which at least 50% of exhumed *Persicaria maculosa* seeds germinate

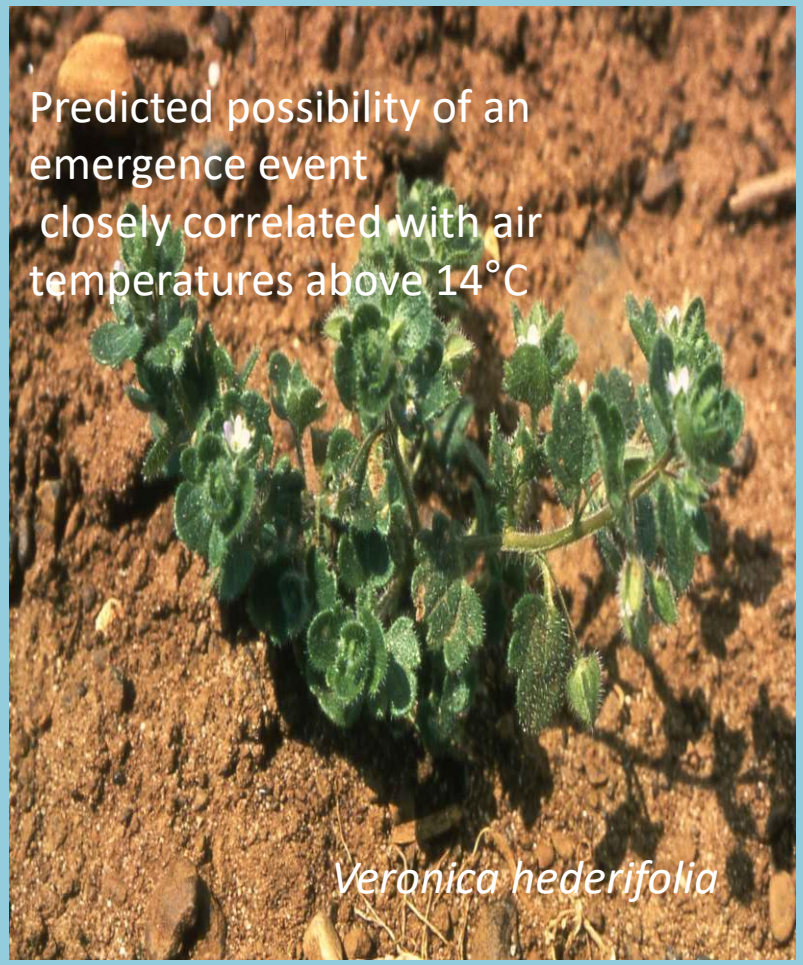




after Vleeshouwers *et al.*, 1995

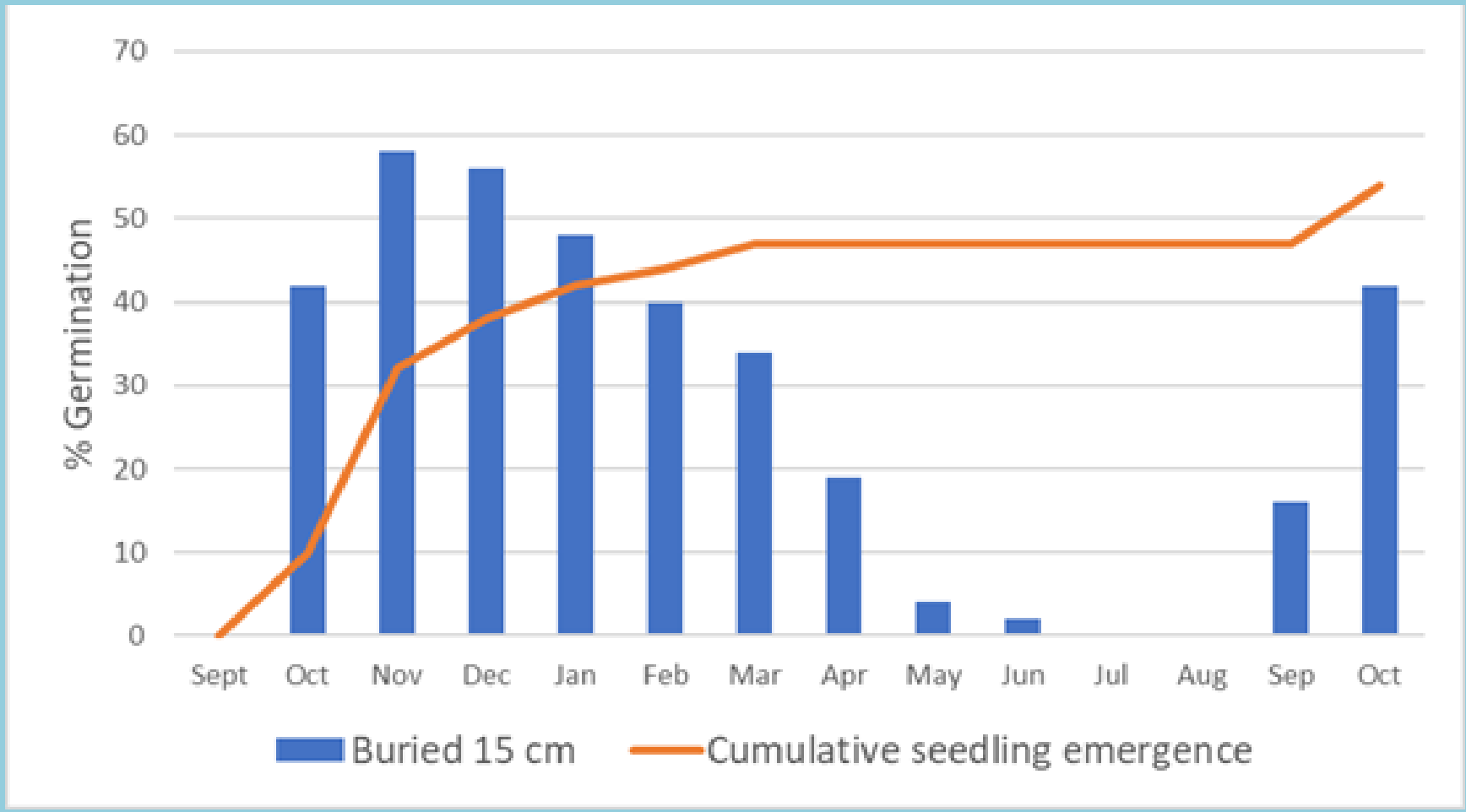
Modelling seedling emergence





after Grundy & Mead 2001

Periodicity of germination and effect of burial on cyclic changes in dormancy of *Galium aparine.*



after Froud-Williams

Effects of Maternal Environment on Seed Dormancy

- Water Stress
- Temperature
- Photoperiod

Effect of water stress on dormancy and germination of *Avena fatua*

		stressed	unstressed
% dormant		80	100
storage	25°	17	90
	5°	75	98
Seedling emergence		66	4

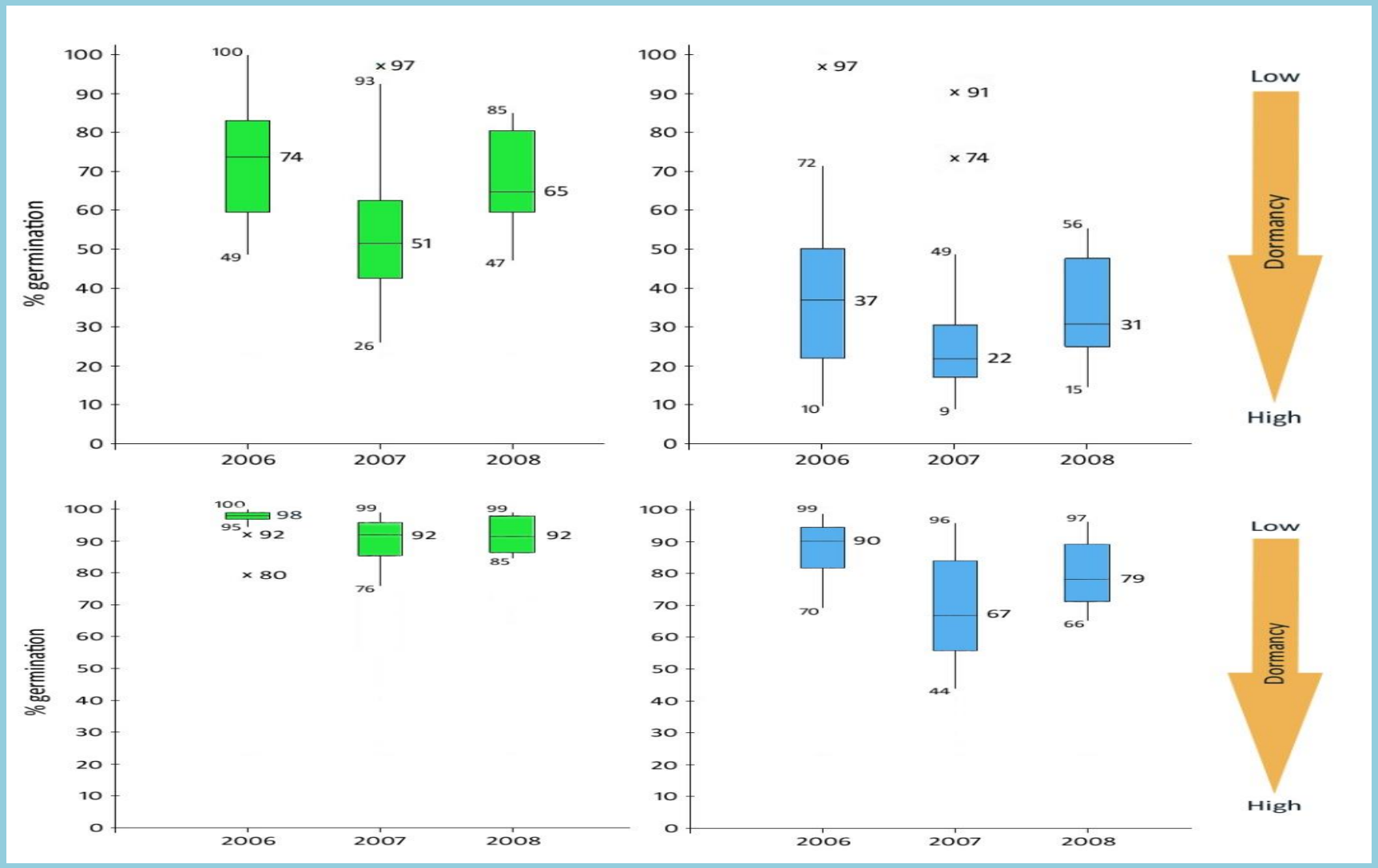
after Peters, 1982

Effect of temperature and water stress on dormancy and germinability of *Avena fatua*

	15°C	20°C
%dormancy	97	63
stressed	47	78
unstressed	10	30

after Peters, 1982

Seed dormancy and germinability of *Lolium multiflorum* 7 days and 2 months after maturation



Tests in Petri dishes with (green) and without (blue) KNO3 solution

% germination of non-dormant *Lolium multiflorum* seed within 7 days of collection and after two months of storage with or without KNO_3

Year	dormancy test (7day)		germn test (2 months)	
	+KNO_3	-KNO_3	+KNO_3	- KNO_3
2006	72	29	97	88
2007	53	36	90	70
2008	68	35	92	80

after Alarcon Reverte, 2009

Identification of Avena spp. phenotypes

Avena fatua

Avena sterilis ssp. ludoviciana

Effect of timing and type of cultivation on density of Avena fatua seedlings m^{-2}

cultivation	timing	1972	1973	1974
autumn	winter			
september	plough	156	184	14
none		80	50	6
september	tine	221	158	14
none		110	43	7

after Wilson 1978

Effect of timing and type of cultivation on density of Avena fatua seeds m^{-2}

cultivation		1972	1973	1974
autumn	winter			
september	plough	256	53	1
none		138	22	1
september	tine	283	41	1
none		56	11	0

after Wilson, 1978

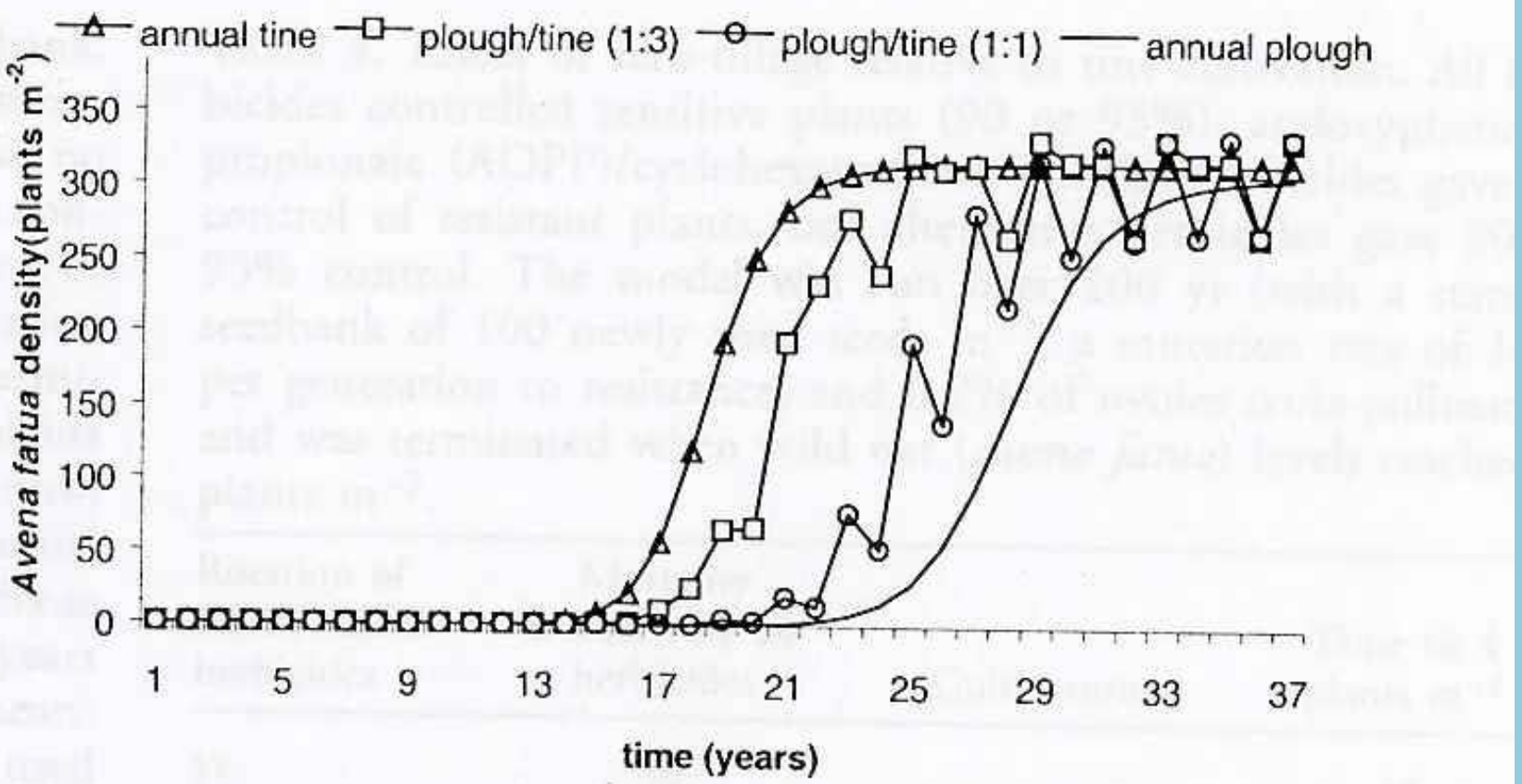
Effects of cultivation regime on long-term decline of *Avena fatua* seedbank in spring barley

	1975		1976		1977
	Feb	June	Feb	June	
Shallow till	580	371	320	9	1
plough	556	528	483	56	12
Direct drill(1)	750	561	450	25	2
Direct drill(2)	614	542	470	88	17

(1) Seeds sown 5cm (2) or 25cm

after Wilson, 1981

Effect of different cultivation regimes on the increase in resistant wild oats assuming annual application of AOPP/CHD herbicides



after Cavan *et al.*,2001

Effect of seed position in spikelet and cultivation on seedling emergence of *Avena fatua*

	1st autumn		1st spring		2nd autumn		2nd spring	
Seed position	proximal	/distal	proximal	/distal	proximal	/distal	proximal	/distal
cultivation	14	5	34	26	16	7	23	51
Mean	9		30		11		37	
No cultivation	13	3	26	9	11	2	32	46
Mean	8		17		6		39	

after Peters 1979

Effect of somatic polymorphism on seed germinability in *Chenopodium album*

		20°C	chill 5°c	chill +NO_3
brown	retic round	>90		
black	retic	62	64	90
black	round	32	61	95

After Williams & Harper,1965

Effect of photoperiod on germination (%) and seed coat thickness of *Chenopodium album*

Incubation temperature 23 °C	Long day 18h light	Short day 16h dark	Short day 16h dark night break 1h ight
Incubation in light	10	92	24
Incubation in dark	0	77	12
Seed coat thickness (µ)	36.8	13.8	14.7

after Karssen, 1970

Seed dynamics summary

	Seed prodn.	Periodicity	annual decay (%)	Survival (yr)
Avena fatua	<200	Sep-May	50/90 (yr1/yr2) 83/96	3-6
Lolium multiflorum	2000	Oct-Apr	>90	2-7?
Anisantha sterilis	200-400	Sept--Mar	90	1-2
Galium aparine	300-400	Oct-May	62-66	1-2
Chenopodium album	3000-20,000	Apr & Aug/Sep	27	7+