Weed Seeds in the Soil.

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In spite of the continued fight the farmer is waging against weeds he finds that these tramps of the vegetable kingdom manage to keep his farm well stocked with their seed and are able to produce abundant crops of their kind every season.

Most weeds produce a great abundance of seed. Single, rather large specimens of crabgrass and foxtail, our two commonest weed-grasses, will produce about 100,000 seeds each. Purslane, pigweeds, speedwell, and Canada fleabane will even exceed this number. Individual plants of many other species of common weeds produce seeds ranging high in thousands. It is readily seen that at this rate of seed production it is not necessary for very many plants to reach maturity in order to keep the soil well seeded.

Blatchley stated, in his Indiana Weed Book, that "Those weeds which are most common and successful in cultivated fields are in general those which by reason of a quick growth are enabled to produce and ripen an enormous number of seeds."

Aside from being able to seed the ground abundantly most of the weed species have also provided their seeds with excellent protective coverings against loss of vitality when unfavorable conditions prevent their germination. Species of Rumex, Plantago, Polygonum, Amaranthus, Chaetochloa, and the Mustard family especially are well known for their ability to remain viable for many years while buried deep in the soil. Seeds of the members of the mustard family owe their longevity, in part, it is claimed, to the great preserving power of the oil which they contain.

Professor Beall[1] found by actual tests that "Shepherd's Purse, Mustards, Purslane, Pigeon-grass, Pigweeds, Peppergrass, Mayweed, Evening Primrose, Smartweed, Narrow-leaved Dock, two Chickweeds, survive when buried in the soil thirty years at least. . . ."

J. S. Grennell,[2] commenting upon the wonderful vitality of mustard seed, made the following statement: "We have known of a piece of ground that had not been ploughed for thirty years at least, which, after the first ploughing in spring, was yellow with the charlock. . . ." Mr. Grennell also stated that "A blackish earth was found beneath an old building known to have existed over two hundred years; when this earth was spread abroad, a quantity of marigold came up all over it, although it had never been seen in that place."

It does not seem possible that the seed of this particular weed would retain its vitality for two hundred years, but such evidently was Mr. Grennel's observation.

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[1] Michigan Agricultural Experiment Station Bulletin No. 260, p. 105.
[2] Report on Agriculture of Massachusetts, 1861, p. 106.

Farmers often report that certain weeds, as red sorrel and white top, for example, spring up in the meadows in great abundance, although they had not been seen there for several years. The story of wheat turning into cheat is no doubt familiar to all. Some farmers also think they have reasons to believe that timothy will turn into red top, cultivated oats into wild oats, and that weeds come up sometimes spontaneously. The followers of such beliefs have evidently not yet realized that the seeds of many weeds may lie dormant in the soil and retain their vitality for many years, and start into growth whenever a favorable opportunity presents itself. The sudden disappearance from the field of some weeds can sometimes be accounted for in a similar way.

As regards the number of viable weed seeds found in the soil several investigations have been made in the past, and some very interesting findings have been reported.

The First Annual Report of the New York (Geneva) Agricultural Experiment Station contains a statement that "On June 22 a single square foot of soil in the garden, which had been plowed and harrowed in the spring, contained 356 growing plants, comprising seven distinct species, not counting clovers and grasses."

Professor Prentiss,[3] of New York, who investigated seven samples of soil taken from different sites and types reported the following results:

A sample taken beside a brook, where the soil had been washed and deposited, contained viable weed seeds at the rate of 13,000,000 per acre.

Another sample taken from a garden also contained weed seeds at the rate of 13,000,000 per acre.

Samples from a compost heap and potting soil produced viable weed seeds at the rate of 34,000,000 and 23,000,000 per acre, respectively.

Muck soil yielded only about 1,000,000 seeds per acre.

A strip of recently plowed sod produced weeds during the season at the rate of 175,000 per acre. Another strip of old sod ground, but cultivated for two or three seasons, produced 80,000 weeds to the acre during the same season.

Dr. Arthur,[4] reported the following results from his investigations at the New York (Geneva) Experiment Station:

8,826 weeds, comprising 45 species, were picked from a strip, covering one-twentieth of an acre, of old pasture land plowed in the spring. Almost one-half of this number was Canada thistle, and over one-fourth foxtail. Another strip of the same size but which had been cultivated during the preceding four years, produced 4,095 weeds, comprising 37 species. Almost one-half of the number was fox-tail.

Two other plots, each one-twentieth of an acre in size, yielded as follows: The first plot which had been cultivated in the spring and cropped the

[3] Transactions of the New York Agricultural Society, 1883-1886, pp. 298-299.

[4] New York (Geneva) Agricultural Experiment Station Annual Reports 1885, pp. 262-265; 1886, pp. 281-283; 1887, pp. 356-363.

preceding season brought forth, during the growing season, 12,068 specimens of weeds, including 28 species; two-thirds of the total was foxtail. The second strip, turned over from an old meadow and adjoining a roadside, produced 38,482 weeds, including 39 species; crabgrass and purslane numbered over one-half of the total.

In another series of similar investigations Arthur secured four samples of soil, two in December and two in April, and placed them in the greenhouse. Plants growing out of these samples were pulled and counted every month for one year.

The following is the record of the number of weeds produced:

A. A square foot of soil, three inches deep, taken in December from a plot which had clean cultivation, produced 29 specimens of grass and 60 specimens of other species of weeds.

B. A square foot of soil, three inches deep, taken in December from a plot which was allowed to run to weeds the previous season, produced 35 specimens of grass and 349 specimens of other weeds.

C. A square foot of soil, one and one-half inches deep, taken in April from the same plot as A, produced 81 specimens of grass and 57 specimens of other weeds.

D. A square foot of soil, one and one-half inches deep, taken in April from the same plot as B, produced 271 specimens of grass and 378 specimens of other weeds.

Bulletin 3, of the Department of Agriculture and Immigration, Winnipeg, Canada, contains the following reference to weeds: "Their seeds are found in all soils, and experiments have been made which show that ordinary garden soil contains 1,300,000 such seeds to the acre."

Hitchcock and Clothier,[5] at the Kansas Agricultural Experiment Station, removed and recorded weed seedlings, for five consecutive seasons, from two plots, of ten square feet, located on poor soil, with the following results:

One plot produced 37,639 weeds, including 79 species, and the other plot produced 70,825 weeds. Purslane, water hemp (Acnida sp.), buffalo bur, stink-grass (Eragrostis major), and Crab-grass were the most common species.

H. S. Fawcett, of the Ames College, Iowa, picked 187,884 weeds, on June 2, on one square rod of garden soil. On another plot, of the same size but which had received more cultivation, he counted 50,736 weeds. Foxtail, Pennsylvania smartweed, Canada fleabane, hedge mustard, and common goosefoot were the most common species.

Another interesting determination was made on the Buzuluk Experimental Field, in Russia, by Bazhanov.[6] He found 3,000 seeds per one square meter of seed bed, two inches deep, or 34,000,000 seeds per one hectar (13,760,000 per acre), and 160,000,000 per hectar (64,750,000 per acre),

[5] Kansas Agricultural Experiment Station Bulletin No. 80, pp. 124-128.

[6] Bulletin Appl. Botany VIII, pp. 276-293. 1915. Extract in Botanisches Centralblatt, Band 129, No. 20, pp. 525-526.

but eight inches deep. The total number of weeds observed on this field included 107 species.

The writer made investigations, during the past five years, along similar lines. In addition to ascertaining the number of viable weed seeds in the different samples of soil used, it was also the intention to learn what difference there was in this respect, between soils carefully tended and those receiving poor cultivation. Still another object was to learn at what depth most of the seeds are usually found, and also what species are most prevalent.

Samples of soils were secured from various sites, during the months of November and December, and placed in boxes or pots in the greenhouse. When the growing weeds were large enough to allow definite determination of the species they were pulled and recorded. This process was continued until all viable seeds had germinated. The soil was stirred occasionally or repotted to hasten germination. All samples were kept for a considerable period after the last specimens of weeds were removed to make sure that all viable seeds had opportunity and time to grow.

In each of the following five samples a square foot of soil was taken to a depth of six inches and separated into the upper and the lower three-inch layers. These samples were secured from the following sites:

1. A rye field, which prior to this time had been repeatedly planted to corn for several years, the crops having been rather poorly tended. (Two samples.)
2. An old abandoned orchard, used to some extent for gardening purposes.
3. An experimental plot on Purdue Farm, used mostly for corn, cowpeas and soy beans. This ground was carefully tended.
4. A garden patch. well tended until midsummer, then allowed to run to weeds.
5. A blue-grass sod, in an old permanent pasture.
6. In addition to the above a cubic foot sample was taken from site No. 1 (the rye field), and separated into the successive inch layers, each layer being potted separately.

The first specimens of weeds were picked, in each case, about a month after the soil samples were potted and placed in the greenhouse. The pulling process was continued, about two months apart, for nearly two years.

Table 1, on the following page, shows the number of plants of each species that grew from the upper and the lower three-inch layers of the various soil samples.

The figures in the table indicate that the grass-weeds are usually the most common intruders in the gardens and fields. This is especially true of crabgrass, which undoubtedly is the most common and persistent grass-weed in the state.

The comparatively large numbers of peppergrass, shepherd's purse, and carpetweed, found in the garden, justify the title of "social weeds," frequently applied to these particular species. They do not seem to be able

TABLE 1.

Number of weed seeds found in the upper and lower three-inch layers of a square foot of soil.

NAME OF WEED.	Location of Soil Sample.											
	Rye Field				Orchard		Purdue Field		Garden		Sod	
	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3″	First 3″	Second 3′
Syntherisma sanguinale	93	49	62	27	64	51	30	30	46	31	...	...
Echinochloa Crus-galli	12	13	...	...	...	...	...	...	...	...	...	...
Chaetochloa glauca	7	1	2	2	33	14	7	5	...	...	...	...
Panicum capillare	3	...	...	...	...	...	...	...	...	2	...	...
Muhlenbergia sp	2	...	...	...	...	...	...	...	...	...	...	...
Eragrostis sp	1	...	31	19	21	24	1	4	10	5	...	...
Poa pratensis	...	...	...	...	...	...	...	...	...	...	5	...
Ranunculus sp	8	16	...	...	...	...	...	...	...	...	...	...
Mollugo verticillata	5	8	32	20	6	21	10	4	100	26	...	...
Amaranthus retroflexus	13	...	14	5	8	20	4	...	1	1	...	...
Convolvulus sepium	1	9	10	...	...	26	3	10	...	...	...	...
Xanthium sp	5	...	...	...	...	...	...	...	...	...	...	...
Portulacca oleracea	3	2	3	5	2	6	...	...	5	15	...	...
Leptilon canadense	4	...	...	4	2	2	...	...	...	...	1	...
Trifolium sp	3	...	1	...	...	1	...	...	...	...	...	1
Polygonum sp	1	2	...	...	...	...	...	...	...	...	...	...
Oxalis stricta	...	3	...	...	8	4	...	3	3	...	3	...
Veronica sp	1	2	2	...	4	9	1	3	6	19	...	...
Lepidium virginicum	2	...	5	1	33	9	3	...	152	35	1	3
Acalypha virginica	1	1	...	...	...	...	...	...	...	...	...	...
Bursa pastoris	1	1	...	1	1	3	...	...	21	43	...	...

Ambrosia artemisaefolia		1										
Alsine media	1				3	1						
Cerastium sp											1	
Taraxaeum sp			1	1	1					1		1
Amaranthus graecizans			1			2		3				
Chenopodium album			2									
Rumex sp				1	3							
Erigeron annuus			1		9	7						
Plantago major					1	2	1		1			
Lactuca scariola												
Euphorbia sp							2	1	1	1		
Solanum melongena									1			
Solanum nigrum										12	3	1
Undetermined	1	10				2						
Total	168	118	167	86	199	204	62	64	347	191	14	8
Calculated per acre	7,318,080	5,140,080	7,274,520	3,746,160	8,668,440	8,886,240	2,700,720	2,787,840	15,115,320	8,319,960	609,840	348,480
Calculated per acre for 6″ layer	12,458,160		11,020,680		17,554,680		5,488,560		23,433,280		958,320	

TABLE 2.

Number of weed seeds found in the successive inch layers of a cubic foot of soil. Sample No. 6.

NAME OF WEED.	Number of the Layer.												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Syntherisma sanguinale	36	22	35	19	16	11	11	9	9	16	6	2	198
Echinochloa Crus-galli	2	6	1	5	5	3		2	2	1			30
Chaetochloa glauca	3	3	1			1	1				1		10
Panicum capillare	3												3
Eragrostis sp.	1								1				2
Muhlenbergia sp.			3										3
Poa pratensis										1			1
Carex sp.											1		1
Amaranthus retrodexus	10	3											13
Xanthium sp.	3	1	1										5
Lepidium virginicum	2				1								3
Leptilon canadensis	3	1											4
Trifolium sp.	1	1	1		1		1			1		1	7
Polygonum sp.	1			1		1				2	1		6
Convolvulus sepium	1			2	2	5							10
Acalypha virginica	1					1							2
Veronica sp.	1					2							3
Ranunculus sp.	1		7	1	4	11							24
Mollugo verticillata	1		4	3	2	3	1						14

Alsine media	1												1
Portulacea oleracea	1	2		1	1				2				7
Bursa pastoris			1			1							2
Ambrosia artemisaefolia				1				1					2
Oxalis stricta				1	2		6	4	2	4	4	1	24
Cerastium sp					1								1
Physalis sp								2	1	1			4
Chenopodium album									1	1			2
Undetermined	1					10							11
Total	73	39	57	34	35	52	23	18	18	27	13	4	393
Calculated per acre	3,179,880	1,698,840	2,482,920	1,481,040	1,524,600	2,265,120	1,001,880	784,080	784,080	1,176,120	566 280	174,240	17,119 080

TABLE 3.
Number of weed seeds calculated per acre.

Reported by	Site or kind of soil	No. of seeds per acre	Remarks
Exp. Station, Geneva, New York	Garden	15,507,360	Picked in June.
Prentiss	Overflow land	13,000,000	
Prentiss	Garden	13,000..000	
Prentiss	Compost	34,000,000	Total depth of soil layer not reported.
Prentiss	Potting soil	23,000,000	
Prentiss	Muck	1,000,000	
Prentiss	Plowed sod	175,000	
Arthur	Plowed pasture	176,520	Growth of current season.
Arthur	Cultivated field	81,900	Growth of current season.
Arthur	Cultivated field	241,360	Growth of current season.
Arthur	Plowed meadow	769,640	Growth of current season.
Arthur	Cultivated field	3,876,840	Total layer of soil 3 inches deep.
Arthur	Neglected field	16,727,040	Total layer of soil 3 inches deep.
Arthur	Cultivated field	6,011,280	Total layer of soil 1½ inches deep.
Arthur	Neglected field	28,270,440	Total layer of soil 1½ inches deep.
Dept. of Agric., Winipeg, Canada	Garden	1,300,000	Current season's growth.
Hitchcock and Clothier	Poor fallow ground	32,791,097	Average of five year's current growth.
Hitchcock and Clothier	Poor fallow ground	61,702,740	Average of five year's current growth.
Fawcett	Garden well tended	8,117,760	Picked in June.
Fawcett	Garden poorly tended	30,061,440	Picked in June.
Bazhanov	Cultivated field	13,760,000	Total layer of soil two inches deep.
Bazhanov	Cultivated field	64,750,000	Total layer of soil eight inches deep.
Pipal	Poorly tended field	12,458,160	Total layer of soil six inches deep.
Pipal	Poorly tended field	11,020,680	Total layer of soil six inches deep.
Pipal	Well tended field	5,488,560	Total layer of soil six inches deep.
Pipal	Permanent pasture	958,320	Total layer of soil six inches deep.
Pipal	Poorly tended garden	23,435,280	Total layer of soil six inches deep.
Pipal	Abandoned orchard	17,554,680	Total layer of soil six inches deep.
Pipal	Poorly tended field	17,075,520	Total layer of soil twelve inches deep.

to hold their own, however, especially the first two, in the open fields where competition is more severe.

The difference in the number of viable seeds found on well tended ground (Purdue plot) and neglected land is very pronounced, showing clearly the value of frequent and thorough cultivation in the control of weeds. Better cultivation of the fields and regular mowing of weeds on fallow and waste land would considerably reduce the ten million dollar loss, which is occasioned yearly in Indiana by the numerous weed pests.

The permanent sod contained, as shown in the table, a comparatively small number of viable weed seeds per square foot.

The second table shows the species and the number of weed seeds contained in the separate inch layers of sample number 6. The figures indicate that the largest number of weed seeds occurs in the surface layer. A large majority of the total number of seeds are contained in the first six inches of the soil layer. This latter fact indicates the depth at which the land in question was usually plowed. Beyond this depth the number of viable seeds is considerably reduced, leaving only four seeds in the twelfth inch, in this particular case, as compared with fifty-two in the sixth inch. At a greater depth than twelve inches the number of weed seeds, found on upland soil, is doubtless very small. On overflow land, however, it is quite likely that many viable seeds are found at considerable depths.

The third table summarizes the total number of weed seeds, calculated per acre, as reported by the investigators mentioned in this paper.

A brief reference to this work has been made in the twenty-eighth Annual Report of the Purdue University Agricultural Experiment Station, pp. 31-32.