The Effect of Reduced Emergence Upon the Proportion of Singles and Doubles in Field Stands of Sugar Beets

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The degree of singleness that is most desirable for the production of optimum field stands is one of the major considerations in the processing of sugar beet seed.

Between 1942 and 1946, when segmented seed was widely used, several operators believed that the problem of reducing the labor required for thinning could best be solved by producing as complete singleness of seed as was possible by mechanical processing. When such seed was planted at low seeding rates where emergence conditions were poor, light and irregular stands often resulted.

Table 1.—Relation of Field Germination to Singleness with Whole, Segmented and Decorticated Beet Seed.

Type of Seed	Size 64th in.	Germination Percent	Seedlings per Viable Unit	Field[1] Germ. Percent	Inch, with singles Percent
Whole	10-12	96.0	1.84	70.4	45.7
Whole	10-12	96.0	1.84	44.5	57.5
Whole	10-12	96.0	1.84	30.1	72.7
Segmented	8-10	92.6	1.38	53.9	70.1
Segmented	8-10	92.6	1.38	30.5	82.8
Decorticated	8-10	95.7	1.89	64.4	48.6
Decorticated	8-10	95.7	1.89	55.5	50.0
Decorticated	7- 9	92.0	1.59	45.2	70.2

[1] Field germination refers to the emergence of seedlings in the field as a percentage ot the total seedlings per 100 seed units as shown by laboratory or greenhouse germination trials.

With the introduction of decortication (l)[2], seed with a higher degree of doubleness was produced and in most cases a more satisfactory stand resulted, although the labor requirement for thinning was somewhat greater than with seed characterized by extreme singleness. Early trials in the precision distribution of graded whole seed showed that the percentage of singles occurring in field plantings was often higher than the percentage of singles shown in laboratory germination. A critical examination of field stands showed that the percentage of singles in field stands was inversely related to the percent of potential emergence. Examples of this relation are shown in Table 1, with graded whole seed, segmented and decorticated seed.

With each seed type there is a noticeable tendency to produce a higher percentage of singles in those trials where the field emergence is the lowest. Seed with a high percent of doubles may under conditions of low emergence produce as high as 70 percent singles in field emergence.

The relative number of singles, doubles and multiples observed in laboratory germination and in field emergence is shown graphically in Figure 1 for two machine plantings, using both segmented and decorticated seed, and for a hand planting using high gravity segmented seed.

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[2] Numbers in parentheses refer to literature cited.

When adjusted to equal seeding rates the data for the Brown planting show that approximately the same number of singles per 100 inches was produced by each of the seeds. More total seedlings, more inches with beets and more doubles and multiples were produced by the decorticated seed, while the segmented seed showed the highest percentage of singles.

A comparison of the laboratory germination and field emergence of the seed lots shows that the percentage of potential emergence for decorticated seed was somewhat higher than for segmented seed and that, per 100 seed units, the decorticated seed produced more singles than segmented as well as more inches with beets and total seedlings. Because of fewer doubles and multiples, the segmented seed shows a higher percentage of single beets. While the segmented seed showed only a small difference in percent of singles between laboratory germination and field emergence, the decorticated seed showed twice the percent of singles in the field than was indicated by the laboratory germination.

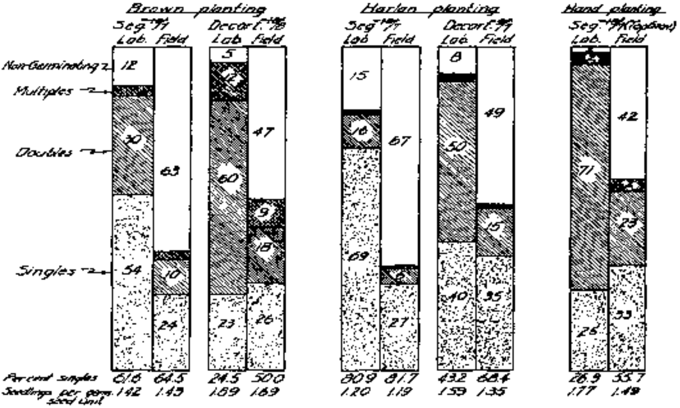

Figure 1.—Comparison of singles, doubles and multiples in laboratory germination and field emergence with three plantings.

In the Harlan planting the results were similar to the Brown planting *in* that the number of singles per 100 inches is about the same for the two types of seed, while the decorticated seed produced more inches with beets and more total seedlings but a lower percentage of singles.

When compared on the basis of emergence per 100 seed units, the decorticated seed again produced a greater number but a lower percentage of singles than segmented seed. Decorticated seed, however, with only 43 percent singles in the laboratory germination, produced 69 percent of singles in the field. Segmented seed with 81 percent singles in the laboratory germination in the same field planting produced 82 percent singles.

The results from these two fields and from a number of other trials by different investigators show clearly that field emergence may show a different proportion of single, double and multiple beets than laboratory germination. It is evident that seed lots containing a high percentage of singles show about the same proportion of singles in field emergence, whereas seed lots made up chiefly of doubles show a decided shift toward singleness in field emergence.

To completely evaluate this relation by experimentation would require a very large number of trials using seed lots with different degrees of multiplicity, each germination at different levels of emergence. Corrections would also have to be made for planter performance, seeding rate and for non-uniformity of the environment within the plots.

Table 2.—Mathematical Expectation, Per 100, that Viable Double-germ Seed Balls Will Produce Single or Double Seedlings with Different Levels of Emergence. Assuming Independent Germination.

Doubles (2.0)

Emergence	0	1	2	Germ. units	Seedlings per seed unit
p_s	p_0	p_1	p_2	p_3	
100 x	$(1-p_s)^2$	$2p_s(1-p_s)$	$(p_s)^2$	$1-p_0$	
100	0	0	100	100	2.00
90	1	18	81	99	1.82
80	4	32	64	96	1.67
70	9	42	49	91	1.54
60	16	48	36	84	1.43
50	25	50	25	75	1.33
40	36	48	16	64	1.25
30	49	42	9	51	1.18
20	64	32	4	36	1.11
10	81	18	1	19	1.05

Symbols

p_s—probability of seedling emergence (percent of potential seedling emergence).
p_0—probability of non-germinating seed unit.
p_1—probability of single seedling.
p_2—probability of doubles.
p_3—probability of seed units producing 1 or more seedlings.

In the opinion of the authors a probable explanation for this phenomenon is the independence or near independence of the germination of individual seeds. In this case the probability of a seed germinating would be about the same whether it occurs in a single or a multiple seed unit. We have, therefore, calculated the results which would be expected with independent germination and then tested the theory by germination trials in a controlled environment and in field plantings.

If we assume independent germination of individual seeds and that environmental conditions within the plot are uniform, we can calculate the mathematical expectation that single, double or multiple seed units will produce blanks, singles, doubles or triples at different levels of field emergence (percentages of potential emergence) . Examples of the application of this formula to double germ seed are presented in Table 2 and Figure 2. In the same way by trinomial expansion a table can be prepared for emergence from triple germ seed.

By applying the formula for probability, as shown in Table 2, we secure an approximation of non-germinating units, single, double or triple seedlings per 100 viable units at any level of emergence for single, double or triple seed balls. It is evident that the multiplicity of emerging seedlings would be strikingly reduced as the percentage of potential seedling emergence is lowered. From these tables it is possible to compute the expectancy, at any level of emergence, from any seed lot for which the percentage of non-viable, single, double and multiple seed units is known. For example, Figure 3 shows the theoretical relation between the laboratory germination and the expectancy of field emergence at different levels of emergence for a seed lot with 1.5 seedlings per viable seed unit.

Emergence Under Controlled Conditions

This relation was next tested by planting four lots of 100-seed units each of whole and decorticated seed in compartmented trays so that the emergence from each seed unit could be followed. This planting was made in pasteurized soil in the greenhouse under ideal germinating conditions and

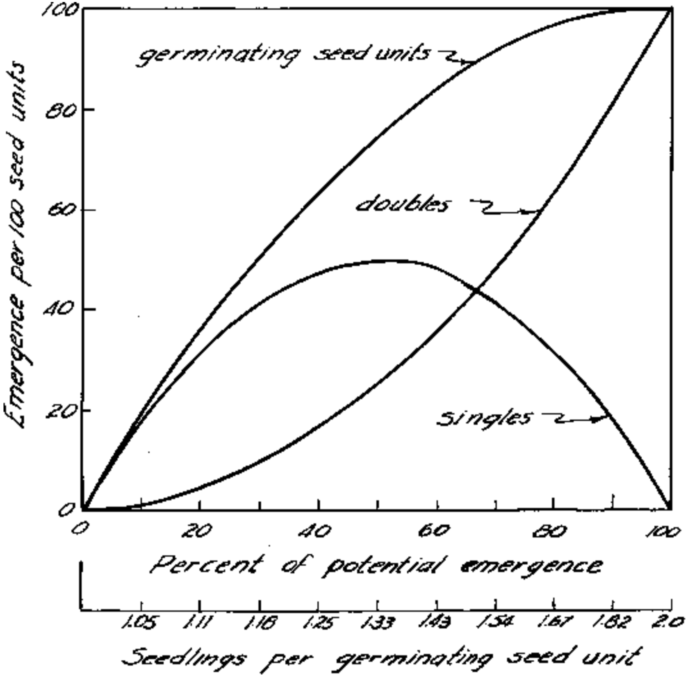

Figure 2.—Mathematical expectation per 100 that double seed balls will emerge as singles or doubles at different percents of potential emergence.

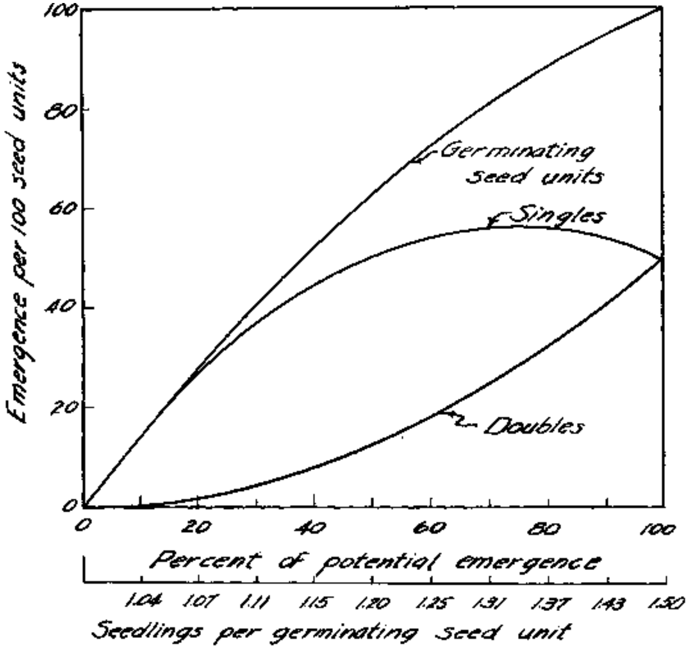

Figure 3.—Anticipated emergence of single and double seedlings at different levels of emergnce from seed units with a laboratory germination averaging 1.5 seedlings per viable seed unit.

observations were recorded at intervals of from 6 to 10 hours from the appearance of the first seedling until emergence was completed. As shown in Table 3 and Figure 4, in practically all cases the first seedlings emerged as singles and later in the germination period a second and sometimes a third or fourth seedling would appear from the same seed **unit.** As emergence progressed the number of seedlings per germination unit increased while the percent of singles decreased.

Under these ideal conditions the percent of singles at the various stages of emergence was nearly identical to the theoretical expectation and it can be concluded, therefore, that emergence of individual seedlings was practically independent.

It is evident also that if emergence of a seedling stand was interrupted by any adverse condition the percentage of single plants would be much

Table 3.—Emergence of Whole and Decorticated Beet Seed from Pasteurized Soil in a Controlled Environment.

	Hours after planting								
	130	136	142	148	156	166	174	192	336
Whole Seed									
Emergence—%	4	10	27	40	60	73	81	91	100
Singles—%	84	87	80	70	53	41	36	31	29
Seedl/germ. unit	1.16	1.13	1.22	1.34	1.51	1.65	1.73	1.83	1.90
Decorticated Seed									
Emergence—%	19	37	55	68	78	86	89	93	100
Singles—%									
Actual	92	85	71	59	56	52	49	45	41
Theoretical	91	83	72	64	57	52	49	46	40
Seedl/germ. unit	1.08	1.15	1.29	1.39	1.45	1.50	1.52	1.56	1.61

higher than if conditions remained uniformly favorable until emergence was completed.

Comparison of Field Data

All of the field data we have observed shows a higher percentage of singles in the field than shown by laboratory germination of the seed. In addition, Doxtator (3) reported tests showing that seed with 26 percent singles produced 56 percent singles in the field at 50 percent of potential emergence and in another trial a seed lot with only 8 percent singles produced 40 percent singles in the field at a 35 percent emergence level.

Using decorticated seed with from 1.55 to 1.65 seedlings per viable seed unit (about 40 percent singles), Tolman (5) found 65 percent singles in the field at 60 percent of potential emergence and 62 percent singles at an emergence level of 57 percent.

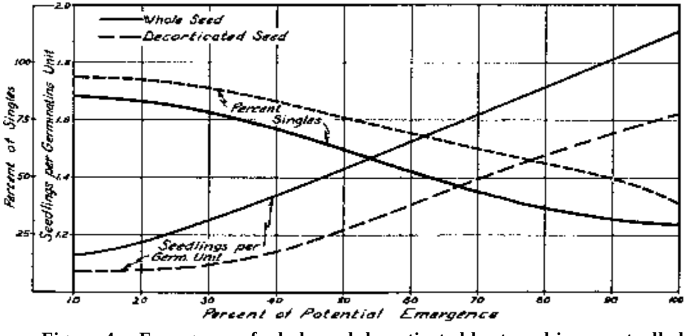

Figure 4.—Emergence of whole and decorticated beet seed in a controlled environment. The percent of singles decreased and the seedlings per germinating seed unit increased as the percentage of potential emergence approached 100.

From a large number of hand-and machine-planted trials Bush (2) concluded that, as an average for all seed lots studied, the percentage of singles in the field was about 12 percent higher than indicated by laboratory germination of the seed.

McBirney (4) analyzed data from a series of planter tests and found that as the percentage of field emergence increased by 1 percent the percentage of singles decreased by 0.51 percent. The slope of his curve was approximately the same as the theoretical expectation, but at the lower emergence levels the proportion of singles was about 15 percent lower than would be expected from independent emergence.

When the same test is applied to other field data it is found in nearly all cases that the proportion of singles is somewhat less than might be anticipated. Partial explanation for this discrepancy can be found in McBirney's data which show that with the same seed lots and the same planter the percent of singles in the field is influenced by the seeding rate. On an average the percentage of singles decreased by 0.6 percent for each increase of one in the number of seedlings per 100 inchs.

In the same way irregular distribution of the seed by the planter would decrease the apparent percentage of singles in the field, especially when measured by the 100-inch stick.

Still another source of variation is the non-uniformity of emergence conditions within the field. Emergence is usually reported as an average percentage for the plot or field, whereas within the area the level of emergence may vary from extremely low to a fairly high percentage of the potential. Such a variation will always tend to produce a lower percentage of singles than would be expected for the average level of emergence.

In general it appears, therefore, that field plantings show the same tendency toward increased singleness with lower levels of emergence as is shown by controlled plantings. Because of the effect of planter distribution, seeding rate and non-uniformity of emergence conditions, most field plantings show a lower percentage of singles than would be expected with completely independent emergence of seedlings.

The practical significance of this relation is the fact that under conditions of low emergence levels there is considerable advantage in leaving a fairly high percentage of doubles in the seed lot because they offer a greater probability of producing at least one seedling than do single germ units. Under extremely favorable conditions, however, the use of a seed lot with a higher percentage of singles offers the greatest possibilities for reducing the labor requirement for thinning.

The seed processor and the growers have the problem of balancing the degree of singleness in the seed lot and the rate of seeding to provide reasonably good field stands under the emergence conditions characteristic of each district.

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