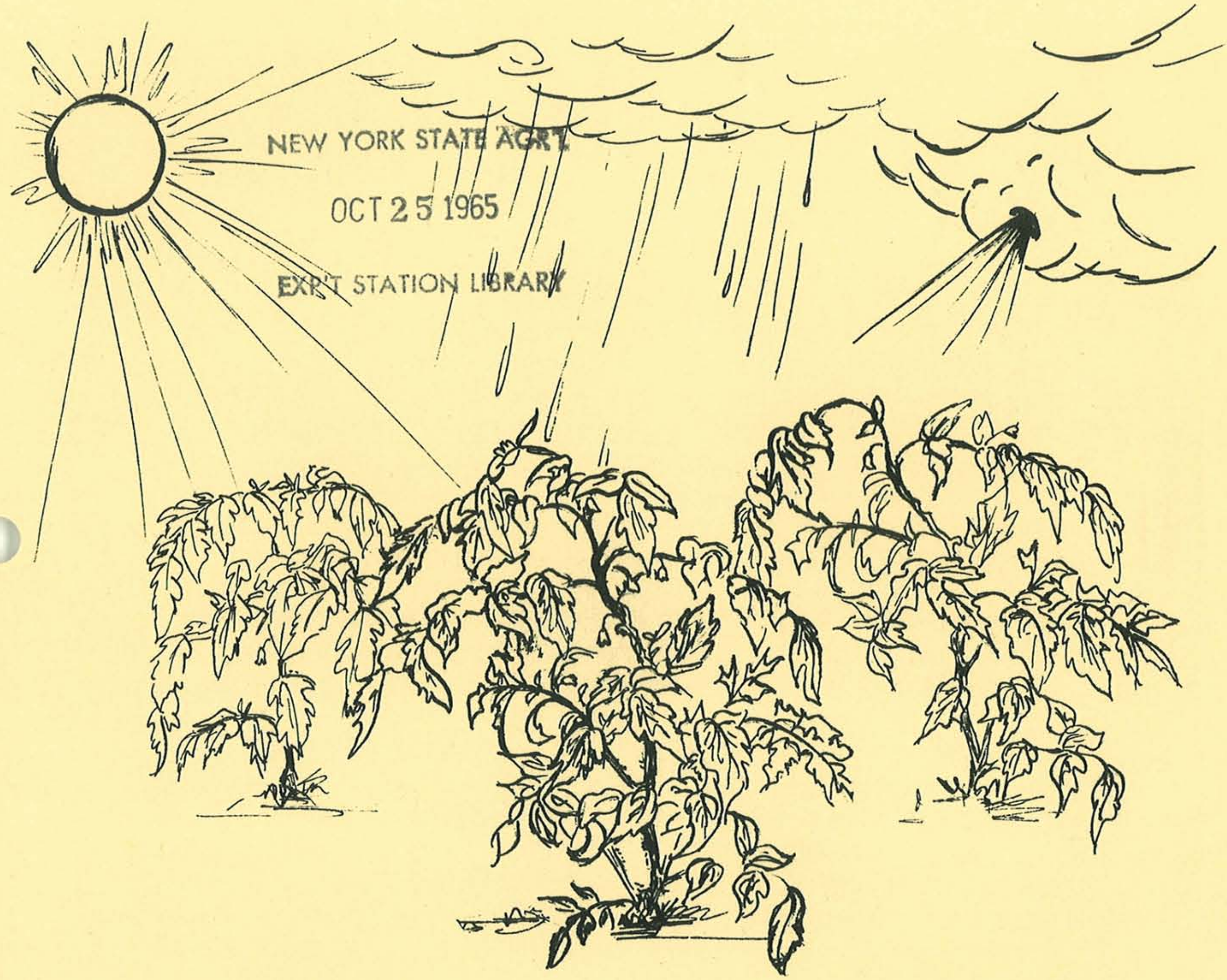
RELATIONSHIP BETWEEN THE VITALITY AND THE PERFORMANCE OF FIREBALL TOMATO SEED



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ABSTRACT

DURING THREE SUCCESSIVE SEASONS, seeds from samples of Fireball Tomato seeds were subjected to adverse storage conditions for varying lengths of time to provide sub-samples which had four different levels of vitality but which were as nearly as possible identical in all other respects. These sub-samples were subjected to standard laboratory germination tests and were used in greenhouse plantings to produce plants for transplanted crops of tomatoes. They were also planted directly in field plots to produce field-seeded crops.

Seeds with lowered vitality had lower total germination percentages and slower rates of germination in standard laboratory tests than seeds with high vitality. The seeds with lowered vitality also germinated more slowly and produced fewer seedlings per 100 germinable seeds in greenhouse and field plantings than those with high vitality.

Lowered vitality of the seed resulted in delayed blossoming and decreased production of mature fruits in early harvests. These effects were more pronounced for the field-seeded than for the transplanted crops. In the field-seeded crops, the lowest vitality seeds produced plants with significantly lower total yields than those produced from the highest vitality seeds. There were no significant differences related to seed vitality in the total yields of the transplanted crops.

IT HAS LONG BEEN RECOGNIZED that the germination behavior of tomato seeds is seriously affected by loss of vitality. It has also been generally recognized that loss of vitality has significance in the establishment of a stand of plants from the seed. The exact relationship between seed vitality and stand establishment, however, has not been completely revealed. There have also been conflicting reports about the relationship between the vitality of seed and the date of maturity and productivity of plants produced from the seed.

The practices of growing field-seeded crops of tomatoes while using pre- and post-emergence applications of herbicides along with the possibility of harvesting tomatoes mechanically have placed more importance on seed performance. Seed vitality is likely to be of greater importance for a field-seeded than for a transplanted crop. This is true because seeds planted directly in the field are likely to be exposed to less favorable conditions than those used for producing transplants. Also, the transplanting procedure provides a better opportunity for discarding retarded plants.

The timing of herbicide sprays can be improved if seedlings emerge from the soil promptly and uniformly. Delayed emergence or emergence prolonged over an extended period of time may seriously interfere with a weed control program.

A one-time harvest commonly used when crops are mechanically harvested requires uniform maturity for maximum yield and top quality. If delayed germination resulting from low seed vitality should cause delayed maturity or lack of uniformity in the maturity of the crop, it could seriously affect the yield and quality of a mechanically harvested crop.

The experiments described in this publication were conducted to determine more definitely the significance of the vitality of tomato seeds under methods of production and harvesting presently in use and those which may come into use in the near future. The Fireball variety was chosen for the experiments since it is suitable for both transplanted and field-seeded crops of tomatoes under New York State conditions.

ESTABLISHING VARYING LEVELS OF VITALITY

For studying the effect of vitality on the performance of seeds, it is desirable to have seeds which differ in vitality but otherwise identical. One way of providing such seeds is to obtain high vitality lots of seeds and then to reduce the vitality of portions of the lots by some suitable means. That was the approach followed in the experiments described below.

Each year for the 3 years (1961, 1962, and 1963) of the experiments, a sample from a new lot of Fireball tomato seed with exceptionally good vitality was obtained. Each year's sample was then divided into sub-samples and exposed to varying storage conditions designed to affect the vitality of the seed.

One portion of each sample was retained as a high vitality control. It was stored under ordinary laboratory conditions until planting time. The other portions were stored for varying periods of time in a chamber held at 100°F with 85 to 100 per cent relative humidity.

In 1961, portions of the seed were stored for 3, 14, and 21 days under the adverse conditions. The 3-day storage, however, was not long enough to have an adverse effect on vitality. In fact, it tended to precondition the seed for planting and resulted in slightly accelerated germination. Therefore, adverse storage periods of 7, 14, and 21 days were used in 1962 and 1963.

The storage periods in a series were so arranged that they were all completed the day the seeds were planted. Since the greenhouse and field plantings were made at different dates, a separate series of storage treatments was used for each. The conditions for both series of storage treatments were kept constant as nearly as was possible.

Since there is no accepted method for specifying levels of seed vitality, the different levels involved in the experiments will be identified on the basis of the adverse storage treatment applied. The seeds with unimpaired vitality will be identified as those which received no adverse storage treatment. The others will be identified as the seeds which received 3-day, 7-day, 14-day, or 21-day adverse storage treatments.

LABORATORY GERMINATION

Following the adverse storage treatments each year, standard laboratory germination tests were conducted to verify that seed vitality had been lowered and to obtain a measure of the comparative amounts by which it had been lowered.

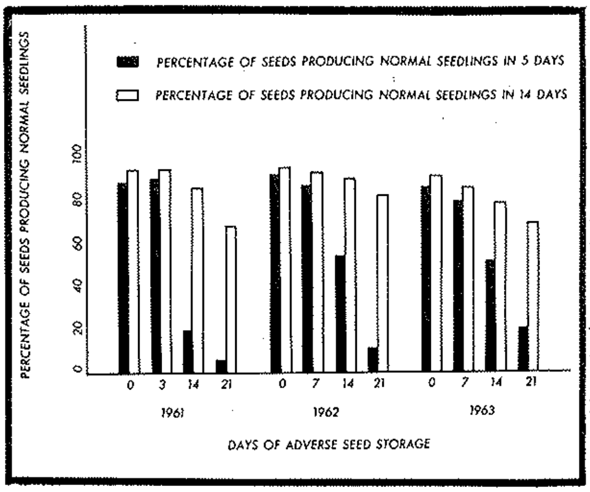

Figure 1. -Relationship between Seed Vitality and Laboratory Germination.

Separate counts of germinated seeds were made after the tests had been in progress for 5 days and when they were complete at the end of 14 days. On each date, all seedlings well enough developed to be classified as normal were counted and removed from the tests.

A summary of the laboratory test results in terms of both the 5-day and 14-day counts is presented in Figure 1. The number of normal seedlings produced in 5 days provides an indication of relative vitality. The slower germinating seeds from the sub-samples which had been exposed to the adverse storage conditions for 14 and 21 day periods were considerably lower in vitality than the seeds which had received no adverse storage treatment.

During three years, the average laboratory germination of the seeds which received no adverse storage treatment was 92 per cent. Those which received 3-day adverse storage treatments in 1961 had an average germination of 93 per cent and those which received 7-day treatments in 1962 and 1963 had an average germination of 88 per cent.

The average germination of all the seeds which were subjected to adverse storage conditions for 14 days was 84 per cent and that of the seeds which were stored under the adverse conditions for 21 days was 72 per cent.

GREENHOUSE STANDS

To provide plants for transplanted crops of tomatoes, seeds from the different seed vitality categories were planted each year in a pasteurized soil mixture in flats in a greenhouse. These plantings were made 4 weeks before the anticipated date for setting the plants in field plots. Eight replicates of 100 seeds each were planted from the seeds in each of the vitality categories.

As soon as seedlings began to emerge from the soil mixture, daily counts were made of the number of emerged seedlings. The counts were continued until 10 days after planting when the emerged seedlings were "spotted out" into other flats to provide the plants needed for the field trials.

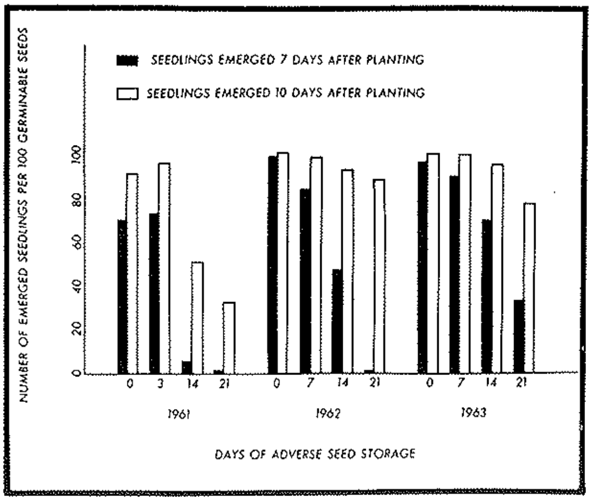

Figure 2. -Relationship between Seed Vitality and Germination in Greenhouse Plantings.

After the counts had been made, the number of emerged seedlings per 100 germinable seeds (seeds capable of producing normal seedlings under favorable conditions in laboratory tests) was calculated. That provided a means of compensating for initial differences in the percentage germination of the seeds in the different vitality categories so that direct comparisons of emergence results could be made.

The effect of lowered vitality on the germination of the seeds in the greenhouse plantings is summarized graphically in Figure 2. The 7-day emergence counts indicated in Figure 2 provide an indication of the relative rate of germination of seeds in the different vitality categories. The 10-day counts indicate the final stands of seedlings at the time that they were of the proper size for "spotting out."

The emergence of seedlings was delayed considerably by the 14 and 21-day adverse storage treatments of the seed. The percentage of germinable seeds that were able to produce seedlings during the 10 day period prior to "spotting out" was also affected by the adverse storage treatments of the seed.

During the 3 years of the experiments, the seeds which received no adverse storage treatments produced an average of 98 seedlings per 100 germinable seeds in the greenhouse plantings. For the seeds which were exposed to 14 days of the adverse storage conditions, 81 per cent of the germinable seeds produced seedlings, whereas only 66 per cent of the germinable seeds from the subsamples stored under adverse conditions for 21 days were able to produce seedlings by "spotting out" time.

FIELD STANDS

To provide field trials of the field-seeded tomatoes, seeds from the different seed vitality categories were treated with thiram and planted in field plots on May 17 in 1961, May 18 in 1962, and May 15 in 1963. Seeds from each storage treatment were planted in 8 different rows with 200 seeds per row.

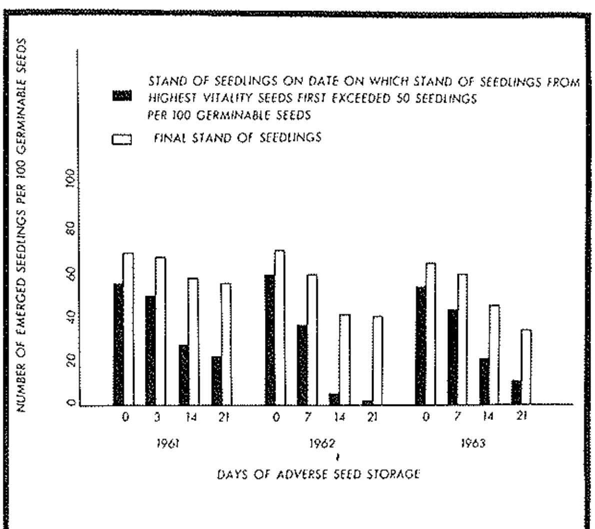

Figure 3. -Relationship between Seed Vitality and Germination in Field Plantings.

The weather was relatively warm in 1962 and seedlings began to emerge 6 days after planting. In 1961 and 1963, on the other hand, rather cool weather prevailed. Seedlings did not emerge until 15 days after planting in 1961 and 13 days after planting in 1963. After the seedlings began to emerge each year, daily counts were made of the number of emerged seedlings, and the number of emerged seedlings per 100 germinable seeds calculated for each seed vitality category.

The summary in Figure 3 indicates the relative rate of emergence of seedlings in the different vitality categories and the relative final stands of plants obtained from them. Although weather conditions at planting time varied from one year to another, the relative performance of seeds in the different vitality categories was about the same each year. Seeds in the low vitality categories had a slower rate of emergence and a poorer final stand of plants than those in the higher vitality categories.

The effect of the lowered vitality of the seeds exposed to adverse storage treatments on their plant producing potential in the field plantings was disproportionate to the effect on laboratory germination percentages. The seeds which had received no adverse storage treatment and which had a laboratory germination of 92 per cent produced an average of 63 plants per 100 seeds (germinable and non germinable) in the 3 years of field plantings. The seeds which had received the 7-day adverse storage treatments had an average laboratory germination of 88 per cent and produced an average of 53 plants per 100 seeds in the 1962 and 1963 field plantings in which they were included.

The seeds which had been exposed to 14 days of adverse storage had an average laboratory germination of 84 per cent and produced 40 plants per 100 seeds in the field plantings. The seeds which had received the 21-day adverse storage treatment had an average laboratory germination of 72 per cent and produced 32 plants per 100 seeds.

A variation from 72 per cent to 92 per cent in laboratory germination was associated with a variation from 32 to 63 plants per 100 seeds in plant production potential in the field plantings. In terms of plant production potential, then, the seeds which germinated 72 per cent in the standard laboratory germination tests had only about half the planting value of those which germinated 92 per cent. In other words, it would have required nearly 2 pounds of the low vitality seeds to produce as many plants as 1 pound of the high vitality seeds.

DATE OF BLOSSOMING

Each year, plants were set in the field for the transplanted crops when the danger of frost had passed. The date of transplanting was June 6 in 1961, June 4 in 1962, and May 27 in 1963. Plants from each seed vitality category were set in

8 replicates with each replicate consisting of a row of 13 plants with the plants 18 inches apart in the row and the rows 5 feet apart.

When plants in the field-seeded plots were well established, they were thinned to provide as nearly as possible the same number of plants in each plot. The plants were thinned to stand as nearly as possible 12 inches apart in 1961 and 18 inches apart in 1962 and 1963.

In the thinning operation, a marker was placed beside the row and the plants nearest to the desired spacings on the marker were left in the row. All others were removed. This method of thinning would correspond to random mechanical thinning in which location rather than size determines whether a plant is left or removed.

After the transplanted crops had been set in the field and the field-seeded crops had been thinned, they were cultivated and sprayed in accordance with recommendations of the New York State College of Agriculture for the production of tomatoes. Both the transplanted and field-seeded plots were irrigated as necessary to provide good growth.

When the plants began to blossom, the date on which the first fully opened blossom appeared on each plant was recorded. The records of blossoming dates thus obtained indicated that, on the average, plants from the low vitality seeds produced their first blossoms later than those from the high vitality seeds. This relationship was more pronounced for the field-seeded crops than for the transplanted crops.

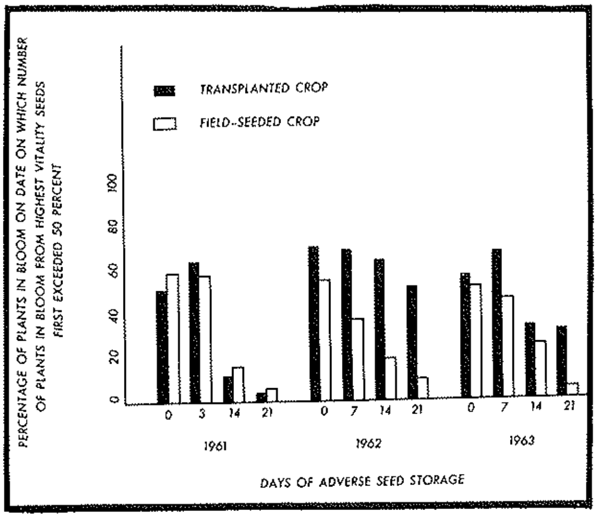

Figure 4. -Relationship between Seed Vitality and Date of Blossoming.

The relationship between seed vitality and date of blossoming is revealed by Figure 4. For the transplanted crops, 50 per cent of the plants from the seeds which received no adverse storage treatment were in bloom 2 days before 50 per cent of the plants from seeds which had received the 21-day adverse storage treatment had blossomed. For the field-seeded crops, 50 per cent of the plants from the highest vitality seeds had blossomed 6 days before 50 per cent of the plants from the lowest vitality seeds were in bloom.

DATE OF MATURITY AND PRODUCTIVITY

As soon as fruits began to mature, they were harvested at 5 to 10 day intervals depending on the rate of ripening. The first fruits were harvested from the transplanted plots on August 17 in 1961, August 16 in 1962, and August 6 in 1963. The first harvests from the field-seeded plots were made on August 23 in 1961, August 16 in 1962, and August 23 in 1963. Final harvests from both the transplanted and field-seeded plots were made on September 29 in 1961, September 13 in 1962, and September 20 in 1963.

In order to provide a uniform procedure for selecting mature fruits and to avoid the loss of fruits from rotting, all fruits showing any red color were picked at each harvest. The weight of fruits picked from each plot was recorded.

The statistical significance of differences in yield associated with seed vitality was determined by "t" tests of paired data. In these tests, yields from the plots planted from seeds of lowered vitality were paired with yields from corresponding plots planted from the highest vitality seeds.

Harvest data for the transplanted plots are summarized in Table 1. For some of the early harvests, plants from the lowest seed vitality category produced significantly smaller amounts of mature fruits than those from the highest vitality category. By the end of the harvest period, however, there were no significant differences in total yield of mature fruits among plants from the different seed vitality categories. The effect of lowered seed vitality seemed to be one of delaying maturity rather than decreasing total yields.

Harvest data for the field-seeded plots are summarized in Table 2. Except for the 1962 season, plants from seed in the lowest vitality category had significantly smaller total yields of mature fruit than those from seed in the highest vitality category. However, relative differences in accumulative yields decreased as the season progressed. With a longer harvest season, therefore, total yields of plants from the low vitality seeds might have reached those of the plants from the high vitality seeds. In a single harvest situation, though, the earlier maturity of the plants from the high vitality seeds would have resulted in a higher yield of mature fruits.

SIGNIFICANCE OF RESEARCH FINDINGS

The data presented in this report confirm some beliefs about seed vitality that have been held without being fully supported by scientific research findings, and tend to refute other such beliefs.

The belief that vitality is an important dimension of seed quality is strongly supported. The data have indicated that good vitality is needed not only for the production of plants from a high percentage of germinable seeds under other than ideal germination conditions but also for the prompt and uniform emergence of seedlings which is so desirable for efficient weed control and other cultural operations.

The data have also focused attention on the fragile nature of seed vitality. Even for tomato seeds which are quite resistant to loss of vitality, a relatively short exposure to conditions of high temperature and relative humidity which could occur naturally had a significant effect on vitality. Many other kinds of seeds would be adversely affected by much shorter periods of exposure to those conditions.

The commonly accepted belief that plants which receive a late start due to delayed emergence of seedlings eventually catch up to plants which receive an early start as a result of prompt emergence is refuted by the data presented in this report. In the experiments conducted, delays in emergence were associated with delays in blossoming and in the maturity of the crop.

The research findings certainly justify efforts now being made to preserve seed vitality through improved seed production, harvesting, processing, and storage procedures. These improvements seem justified even though they are likely to increase the per pound cost of seeds.

Table 1. - Relationship Between Seed Vitality and Weight of Fruit Per Plant Harvested from Plants in the Transplanted Plots.

Seed Storage Treatment	Accumulative Weight (Pounds) of Fruit Per Plant Through Harvest Indicated:							
	1st	2nd	3rd	4th	5th	6th	7th	8th
1961								
No Adverse Storage	0.3	1.4	2.9	4.4	6.5	8.4	9.9	10.6
3-day Adverse Storage	0.3	1.6	3.3*	4.9	7.1	9.0	10.4	11.1
14-day Adverse Storage	0.2	1.1*	2.6	4.0	7.0	9.4	10.7	11.5
21-day Adverse Storage	0.2	0.8**	2.1**	3.5*	6.4	9.0	10.3	11.0
1962								
No Adverse Storage	0.5	2.2	5.0	7.9	8.8	--	--	--
7-day Adverse Storage	0.3	2.1	5.0	7.6	8.3	--	--	--
14-day Adverse Storage	0.4	2.0	5.0	7.8	8.5	--	--	--
21-day Adverse Storage	0.3	1.8*	4.6	7.2	8.2	--	--	--
1963								
No Adverse Storage	0.1	1.6	2.6	4.3	7.8	9.5	10.6	--
7-day Adverse Storage	0.1	1.8	2.8	4.5	8.0	9.7	10.8	--
14-day Adverse Storage	0.0*	1.3	2.1*	3.6	6.8	9.0	10.3	--
21-day Adverse Storage	0.0*	1.1**	2.1**	3.6**	7.0*	9.1	10.6	--

* Odds were greater than 19 to 1 but less than 99 to 1 that the difference between this value and the corresponding value for seeds which received no adverse storage treatment was not due to chance.

** Odds were 99 to 1 or better that the difference between this value and the corresponding value for seeds which received no adverse storage treatment was not due to chance.

Table 2. - Relationship Between Seed Vitality and Weight of Fruit Per Plant Harvested from Plants in the Field-seeded Plots.

Seed Storage Treatment	Accumulative Weight (Pounds) of Fruit Per Plant Through Harvest Indicated:						
	1st	2nd	3rd	4th	5th	6th	7th
1961							
No Adverse Storage	0.1	0.4	1.2	4.8	7.3	8.2	8.6
3-day Adverse Storage	0.1	0.4	1.2	4.7	7.1	8.0	8.4
14-day Adverse Storage	0.1	0.1**	0.6**	3.1**	5.9*	7.1	7.5
21-day Adverse Storage	0.1	0.1**	0.5**	2.7**	5.5**	6.8*	7.2*
1962							
No Adverse Storage	0.1	1.3	3.4	5.0	5.4	--	--
7-day Adverse Storage	0.1	0.9*	3.1	4.8	5.3	--	--
14-day Adverse Storage	0.0	0.6**	2.2**	3.7*	4.4*	--	--
21-day Adverse Storage	0.0	0.4**	1.7**	3.6**	4.6	--	--
1963							
No Adverse Storage	0.1	0.6	1.7	4.6	7.5	--	--
7-day Adverse Storage	0.1	0.7	1.8	4.4	7.5	--	--
14-day Adverse Storage	0.0	0.4	1.2*	3.5	6.3	--	--
21-day Adverse Storage	0.0	0.2**	0.8**	2.6**	5.3**	--	--

* Odds were greater than 19 to 1 but less than 99 to 1 that the difference between this value and the corresponding value for seeds which received no adverse storage treatment was not due to chance.

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