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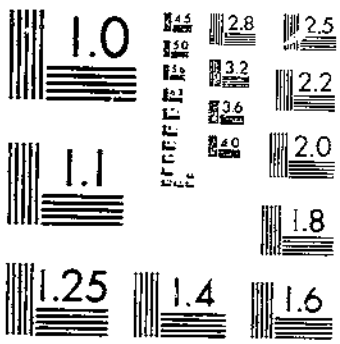
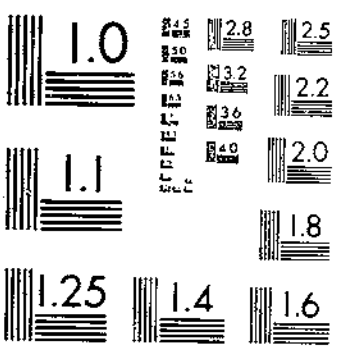


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963 A

VIABILITY OF STORED SNAP BEAN SEED AS AFFECTED BY THRESHING AND PROCESSING INJURY

By Eben H. Toole and Vivian K. Toole

Technical Bulletin No. 1213

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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Washington, D.C. Issued February 1960

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price 10 cents

VIABILITY OF STORED SNAP BEAN SEED AS AFFECTED BY THRESHING AND PROCESSING INJURY

By EBEN H. TOOLE,[1] *principal physiologist*, and VIVIAN K. TOOLE,[2] *plant physiologist, Crops Research Division, Agricultural Research Service*

In order to test the influence of various factors on the loss of viability of snap bean seeds in storage, a study was made in 1948–52 of seeds of several varieties, with various degrees of threshing and processing injury, stored under various commercial conditions. The seed lots used had been evaluated in 1948 and 1949, directly after harvesting and processing, in a study [3] of mechanical injury of snap bean seeds in relation to seed germination and seedling defects. Preliminary reports on the storage study have appeared in earlier publications.[4] Bean harvesting and processing machinery, and storage problems in regard to bean seed viability, have not changed since the initiation of this study. The information provided herein is basic and applicable to current problems.

Four seed companies cooperated, providing storage facilities and large bulk lots of commercially processed seeds and assisting otherwise.[5]

MATERIAL AND GENERAL METHODS

The seeds used came from 13 of the 50 individual bulk lots of bean seed of the 1948 crop and the 4 bulk lots of the 1949 crop that had been tested for threshing and processing damage.[3] The 1948 lots were of the varieties Black Valentine, Bountiful, Brittlewax, Plentiful, and Tendergreen; the 1949 lots were of the newer varieties Logan and Topcrop. Care was taken to select lots of the 1948 crop in which percentages of injured seeds and also severity of injuries ranged from low to high.

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[1] Retired January 1959.

[2] Technical assistance was received from B. J. Lay and Elizabeth H. Bridge, formerly of the Crops Research Division, Agricultural Research Service.

[3] TOOLE, E. H., TOOLE, VIVIAN K., LAY, B. J., and CROWDER, JANICE T. INJURY TO SEED BEANS DURING THRESHING AND PROCESSING. U.S. Dept. Agr. Cir. 874, 10 pp., illus. 1951.

[4] TOOLE, E. H. RELATION OF SEED PROCESSING AND OF CONDITIONS DURING STORAGE TO SEED GERMINATION. Internatl. Seed Testing Assoc. Proc. 16: 214–225, illus. 1950.

TOOLE, E. H., and TOOLE, VIVIAN K. RELATION OF STORAGE CONDITIONS TO GERMINATION AND TO ABNORMAL SEEDLINGS OF BEAN. Internatl. Seed Testing Assoc. Proc. 18: 125–129, illus. 1953.

[5] The companies were Associated Seed Growers, Inc., New Haven, Conn.; Corneli Seed Co., Inc., St. Louis, Mo.; Northrup, King & Co., Minneapolis, Minn.; and F. H. Woodruff & Sons, Inc., Milford, Conn. All contributed seed and use of open warehouses, and the first- and last-named also provided use of air-conditioned storage rooms.

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The three general localities in which the seeds used originated, and the code letters applied to seed lots from the individual areas, are as follows: Sacramento, Calif. (C); Twin Falls, Idaho (A, D, E, and F); and Basin, Wyo. (B).

Each bulk lot of seed was divided into bushel lots, of which one was stored in an open warehouse at the place of origin and others were shipped in December of the crop year for storage at one or more of three other locations. All together, the storage locations represented a wide range of climate. Two southern storage locations were used, both in Texas—Mercedes, in the lower Rio Grande Valley near the winter-vegetable-producing area, and San Antonio, where temperature and humidity conditions are slightly less severe. Milford, Conn., was used as representing northeastern coastal localities. At each of these three locations, seed lots were stored in an open warehouse and also in a room where some control was maintained over air temperature and humidity. (Such a room is referred to hereafter as a controlled storage.) Bushel lots coded A were stored at their place of origin and at Mercedes, San Antonio, and Milford. Lots coded B, E, and F were stored at their places of origin and at Mercedes and San Antonio. Lots coded C and D were stored at their places of origin and at Mercedes.

The storage period of the 1948 seed totaled 45 months; that of the 1949 seed, 33 months.

Temperature and relative humidity were recorded at the Texas storage places by means of hygrothermographs. These instruments were checked occasionally by local weather officers, but it is realized that the values obtained are only approximate. Means of temperature and relative humidity prevailing at places of storage are presented in table 1.

All bulk lots were sampled by the cooperating seed companies in the localities of origin before bushel lots were shipped. The shipped lots were sampled when received at the places of storage early in January.

TABLE 1.—*Temperature and humidity conditions*[1] *at places of storage*

Kind and location of storage	Mean temperature			Mean relative humidity		
	November–April	May–October	Average	November–April	May–October	Average
	°F.	°F.	°F.	*Percent*	*Percent*	*Percent*
Controlled storage:						
Mercedes, Tex.	63	68	65	61	53	57
San Antonio, Tex.	62	62	62	32	38	35
Open warehouse:						
Basin, Wyo.	29	61	45	65	57	61
Mercedes, Tex.	70	85	77	62	62	62
Milford, Conn.	39	64	52	71	73	72
Sacramento, Calif.	51	69	60	75	57	66
San Antonio, Tex.	61	79	70	57	57	57
Twin Falls, Idaho	35	63	49	69	45	57

[1] Data for Mercedes and San Antonio storages were derived from hygrothermograph records. Those for the other storages were derived from records of the U.S. Weather Bureau.

Thereafter, all bushel lots were sampled at 3-month intervals. Each time, each lot was stirred by hand and a 1-quart sample was drawn from it and placed in a moisture can. The samples were shipped by express to the Plant Industry Station, Beltsville, Md., where their seed moisture content was determined and they were subjected to germination tests.

After preliminary checking with oven tests, all moisture determinations were made with a Steinlite moisture meter.

At each testing period, each sample was tested for viability by two methods. A standard upright-rolled-towel test was made on 8 replicates of 50 seeds each at a 20° and 30° C. daily alternation of temperatures, and a greenhouse test was made on 4 replicates of 100 seeds each in flats containing a sterilized mixture of muck and sand. The soil mixture was suitably wetted before the seeds were planted, and water was added to it as needed about the third day after planting. Germination counts were made after 8 days in the rolled-towel test and after 14 days in the greenhouse test.

A seed was considered to have germinated only if it produced a seedling capable of developing into a plant having field value. Because seed lots producing high proportions of seedlings showing no defects were to serve as controls for measuring loss of viability in storage due to harvesting and processing damage, the field-value seedlings were classified into two groups. These were (1) seedlings showing no defects and (2) seedlings showing slight to moderate defects.

RESULTS

After the seed lots were stored, about 2 months elapsed before they reached moisture equilibrium with the storage environment. The mean moisture content of each seed lot for each location and each kind of storage is shown in table 2. Each of the tabulated values represents 11 or 15 determinations made at 3-month intervals. Although seed moisture content tended to vary slightly according to bean variety, a general pattern of mean seed moisture content according to air humidity is evident for each location and kind of storage.

Significantly higher germination percentages were obtained in the greenhouse tests than in the rolled-towel tests. However, the differences between the results obtained by the two methods average only about 2 percent. Accordingly, germination percentages obtained in the greenhouse tests have been averaged with those obtained in the rolled-towel tests.

All bulk lots except 2, it appears, were adequately mixed before they were divided; for 15 of the 17 bulk lots, the result of the first postshipment germination test of each lot shipped for storage corresponded closely with that of the original test. For lot B of variety Tendergreen, the germination value obtained by testing the first sample sent from place of origin exceeded by 10 percent or more that obtained by testing any of the first samples taken at other places of storage or any subsequent sample taken at the place of origin. Therefore, the original sample did not represent the bushel lot stored at place of origin or at any other storage place. For lot B of variety Bountiful, the germination of samples sent from place of origin during the period of stor-

TABLE 2.—*Mean moisture content of each seed lot for storage period, by location and kind of storage*

Crop year and bean variety	Lot	Locality of seed origin	Mean moisture content (with standard deviation)[1] of seed stored as indicated						
			Warehouse at place of origin	Mercedes, Tex.		San Antonio, Tex.		Milford, Conn.	
				Warehouse	Controlled storage	Warehouse	Controlled storage	Warehouse	Controlled storage
1948			*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Black Valentine	A	Twin Falls, Idaho	8.7±0.44	13.3±0.70	11.7±0.72	11.1±0.85	7.9±0.52	15.4±1.77	10.5±0.67
	B	Basin, Wyo	9.2±.39	13.1±.87	11.9±.79	11.3±1.19	8.0±.54		
	C	Sacramento, Calif	11.7±1.36	15.4±1.14	12.9±.93				
Bountiful	B	Basin, Wyo	9.7±.53	14.0±1.03	12.2±.68	11.7±1.20	7.9±.36		
	C	Sacramento, Calif	11.5±1.18	14.5±.90	12.7±.64				
	D	Twin Falls, Idaho	8.0±.65	14.1±.77	12.4±.67				
Brittlewax	A	do	9.4±.41	14.0±.46	12.3±.65	11.6±.86	8.7±.38	15.2±1.44	11.4±.62
	B	Basin, Wyo	9.8±.51	14.1±.36	12.3±.67	11.7±1.13	8.6±.37		
	D	Twin Falls, Idaho	8.6±.48	14.1±.51	12.1±.58				
Plentiful	A	do	8.7±.47	15.5±.66	11.4±.73	11.0±1.16	7.8±.37	15.0±1.49	10.5±.60
Tendergreen	A	do	8.9±.30	12.6±.40	11.5±.41	11.1±.82	8.3±.25	13.7±.87	10.6±.66
	B	Basin, Wyo	9.2±.38	12.5±.35	11.3±.48	10.8±.85	8.4±.39		
	D	Twin Falls, Idaho	8.5±.41	12.8±.34	11.6±.43				
Mean			[2]	13.8	12.0	11.3	8.2	14.8	10.7
1949									
Logan	E	Twin Falls, Idaho	8.7±0.20	13.7±0.52	12.1±0.63	11.5±1.24	8.5±0.41		
	F	do		13.5±.69	12.4±.78	11.5±1.26	8.7±.34		
Toperop	E	do	9.2±.16	12.8±.59	11.7±.56	11.1±.69	9.1±.29		
	F	do		12.7±.55	11.7±.62	11.2±.86	9.1±.26		
Mean			8.9	13.2	12.0	11.3	8.8		

[1] Each mean for a 1948 lot represents results of 15 tests at intervals of 3 months; each mean for a 1949 lot represents results of 11 such tests.

[2] For seed stored in California, Idaho, and Wyoming, respectively, moisture content averaged 11.6, 8.7, and 9.5 percent

age exceeded from the beginning those of samples sent from other storages, including San Antonio controlled storage. It appears that in this instance the bushel lot held at place of origin was not identical with those sent to Mercedes and San Antonio.

The seed lots stored at place of origin and those stored under controlled conditions at Milford and San Antonio did not fall in germination within the 33 or 45 months of the full storage period. (Data for original germination at place of origin are lacking for the F lots of Logan and Topcrop.) The periods without decrease of germination in other storage places are shown in table 3. Basic germination values used in determining these periods were derived by averaging the germination values of all the samples of lots alike in variety and origin (for example, the A lots of Black Valentine) that were tested after storage in the place or places where the germination did not decrease within the storage period. The number of seeds represented by a basic germination percentage, according to number of storage places in which the germination did not decrease, is as follows: Three storages, 38,400 seeds; two storages, 25,600 seeds; one storage, 12,800 seeds. The least difference from the basic value that was significant at the 1-percent level was taken as the standard of significant decrease.

In the warehouse at Mercedes, seed lots of the five older varieties decreased in germination to some extent within 9 months or less and those of Logan and one of Topcrop did so within 15 months or less. The seeds of Topcrop tended to keep longer than those of Logan under controlled conditions at Mercedes and in the warehouse at San Antonio. Seeds of Topcrop, on the whole, did not keep quite so long as those of Black Valentine, Bountiful, and Tendergreen in the controlled storage at Mercedes, but they resembled them closely in response when held in the warehouse at San Antonio. Of the older varieties, Brittlewax and Plentiful decreased in germination sooner than the others.

Original and basic percentages of seedlings showing no defects and the periods of storage without significant change from the basic percentages are given in table 4. Original percentage of perfect seedlings differed markedly between lots within a variety. The lot producing the greatest original percentage of perfect seedlings among lots of any one variety was likewise the lot highest in original germination (tables 3 and 4). Where germination fell, in general it fell less rapidly for lots that had high original percentages of perfect seedlings than for others. Percentage of perfect seedlings decreased within the storage period, even for seed lots for which percentage of field-value seedlings remained unchanged. The time when such a decrease first became evident for seed lots of this category preceded the end of the experiment by about 12 to 21 months for the 1948 lots and by about 15 months for the 1949 lots.

It was not always possible to determine by observation whether a decrease in percentage of perfect seedlings did or did not result from slight mechanical injuries to seed such as had not manifested themselves in earlier tests. Some of the defects that appeared in seedlings produced from stored seed could not be positively identified as caused by mechanical injury to seed but were similar in appearance to defects known to have been so caused.

TABLE 3.—*Original and basic germination of seed lots and the periods of storage (measured in 3-month intervals) before germination decreased, by location and kind of storage in which it decreased*

Variety	Lot	Original germination	Basic germination [1]	Least difference from basic germination significant at 1-percent level	Period of storage without significant decrease of germination			
					Mercedes, Tex.		San Antonio, Tex., warehouse	Milford, Conn., warehouse
					Warehouse	Controlled storage		
		Percent	*Percent*	*Percent*	*Months*	*Months*	*Months*	*Months*
Black Valentine	A	83	83 (3)	3.9	6	30	27	33
	B	77	79 (2)	6.2	6	30	27	----------
	C	95	95 (1)	3.0	6	42	----------	----------
Bountiful	B	78	80 (2)	5.0	3	30	27	----------
	C	94	94 (1)	4.3	6	33	----------	----------
	D	89	87 (1)	4.7	3	24	----------	----------
Brittlewax	A	93	92 (3)	4.0	6	15	15	21
	B	75	78 (2)	3.7	3	3	6	----------
	D	85	84 (1)	4.5	0	12	----------	----------
Plentiful	A	91	91 (3)	2.5	3	18	9	39
Tendergreen	A	92	93 (3)	2.5	6	33	27	36
	B	75	63 (2)	5.2	3	9	27	----------
	D	83	80 (1)	6.5	6	30	----------	----------
Logan	E	61	60 (2)	6.3	12	24	18	----------
	F	----------	71 (4)	6.4	3	12	9	----------
Toperop	E	76	76 (2)	6.3	15	27	27	----------
	F	----------	83 (4)	4.5	12	27	24	----------

[1] Average of mean germination percentages for storages in which germination did not decrease within the storage period. Numbers in parentheses indicate these storages as follows: 1, place of origin; 2, place of origin and San Antonio controlled storage; 3, place of origin and Milford and San Antonio controlled storages; 4, San Antonio controlled storage.

TABLE 4.—*Original and basic percentages of seedlings showing no defects produced in germination tests and the periods of storage before decrease from the basic percentages occurred, by location and kind of storage*

Variety	Lot	Original percentage of seedlings showing no defects	Basic percentage of seedlings showing no defects [1]	Least difference from basic percentage significant at 1-percent level	Period of storage without significant decrease in percentage of seedlings showing no defects						
					Warehouse at place of origin	Mercedes, Tex.		San Antonio, Tex.		Milford, Conn.	
						Warehouse	Controlled storage	Warehouse	Controlled storage	Warehouse	Controlled storage
				Percent	*Months*	*Months*	*Months*	*Months*	*Months*	*Months*	*Months*
Black Valentine	A	64	63 (3)	7.29	30	6	24	24	33	21	24
	B	63	61 (3)	11.37	30	6	27	18	33	----	----
	C	89	85 (1)	7.43	27	6	24	----	----	----	----
Bountiful	B	56	47 (2)	3.73	[2]	6	18	9	27	----	----
	C	87	85 (1)	9.57	33	12	24	----	----	----	----
	D	77	72 (1)	9.86	39	9	27	----	----	----	----
Brittlewax	A	80	76 (3)	6.39	30	3	9	12	30	15	24
	B	53	50 (3)	5.32	24	3	6	6	27	----	----
	D	73	67 (1)	8.93	24	6	12	----	----	----	----
Plentiful	A	75	72 (3)	7.81	33	6	18	24	30	24	30
Tendergreen	A	76	76 (3)	11.63	30	6	24	24	33	24	33
	B	51	30 (3)	12.22	27	6	24	27	27	----	----
	D	61	52 (1)	9.29	27	12	24	----	----	----	----
Logan	E	34	30 (3)	9.16	18	12	18	18	18	----	----
	F	----	39 (2)	13.37	----	6	15	15	18	----	----
Toperop	E	51	49 (3)	7.25	15	12	15	18	18	----	----
	F	----	53 (2)	17.42	----	12	24	24	30	----	----

[1] The basic percentage for a given lot of seed was derived by averaging the percentages of such seedlings obtained in the first 12 months' tests of seed stored at places indicated in parentheses as follows: 1, place of origin; 2, controlled storage at San Antonio; 3, place of origin and controlled storage at San Antonio.

[2] No change.

Minimum germination standards established under the Federal Seed Act [6] for vegetable seeds offered for sale in interstate commerce are 70 percent for Logan and Toperop, 75 percent for the other bean varieties used in this study. The rates at which seed lots having basic germination percentages of more than 80 fell below the minimum germination standards at Mercedes and in the warehouses at Milford and San Antonio are shown in table 5.

TABLE 5.—*Basic germination of 9 bean seed lots* [1] *of 6 varieties and the periods of storage (measured in 3-month intervals) before germination fell below the minimum standard, by location and kind of storage*

Variety	Lot	Basic germination	Period of storage without decrease of germination below the minimum standard [2]			
			Mercedes, Tex		San Antonio, Tex., warehouse	Milford, Conn., warehouse
			Warehouse	Controlled storage		
		Percent	*Months*	*Months*	*Months*	*Months*
Black Valentine	A	83	9	39	30	36
	C	95	9	[3]		
Bountiful	C	94	12	39		
	D	87	6	30		
Brittlewax	A	92	6	42	27	30
	D	84	3	27		
Plentiful	A	91	12	39	36	[3]
Tendergreen	A	93	12	42	33	42
Toperop	F	83	15	[3]	30	

[1] The lots excluded from this table are those the basic germination percentages of which were 80 or less.

[2] For Black Valentine, Bountiful, Brittlewax, Plentiful, and Tendergreen, 75 percent; for Toperop, 70 percent.

[3] Germination did not fall below the minimum standard within the storage period.

SUMMARY

Snap bean seed from 13 bulk lots of 5 varieties harvested in 1948 and commercially processed were stored for 45 months in open warehouses in the localities of California, Idaho, and Wyoming where the seed had originated and also in open warehouses and controlled storages at 1 or more of 3 other locations—Mercedes and San Antonio, Tex., and Milford, Conn. The varieties represented were Black Valentine, Bountiful, Brittlewax, Plentiful, and Tendergreen. Seed from two commercially processed bulk lots each of the newer varieties Logan and Toperop, harvested in 1949, were stored for 33 months

[6] UNITED STATES AGRICULTURAL MARKETING SERVICE. RULES AND REGULATIONS UNDER THE FEDERAL SEED ACT. Service and Regulatory Announcements No. 156, 65 pp. Amended. 1956.

in open warehouses at the place of origin and also in the warehouses and controlled storages in Texas. Moisture and germination tests of all the seed lots were made at the beginning of the storage period and at 3-month intervals thereafter. Lots producing high proportions of seedlings showing no defects served as controls for measuring loss of viability in storage due to harvesting and processing damage.

No seed lot showed a significant change of germination percentage during the entire period of storage at the place of origin or in the controlled storage at Milford or that at San Antonio.

All lots deteriorated rapidly in the open warehouse at Mercedes, where temperature and humidity were high. Seeds remained viable much longer in the Mercedes controlled storage, the San Antonio open warehouse, and the Milford open warehouse than in the open warehouse at Mercedes.

Seeds of the varieties Brittlewax and Plentiful deteriorated more quickly than any others.

The lot producing the greatest original percentage of perfect seedlings among lots of any one variety was likewise the lot highest in original germination. Where germination fell, in general it fell less rapidly for lots that had high original percentages of perfect seedlings than for others of the same variety.

Percentage of perfect seedlings decreased within the storage period, even for seed lots for which percentage of field-value seedlings remained unchanged.

U.S. GOVERNMENT PRINTING OFFICE: 1960

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