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Recommendations

FOR optimum yield of snap bean seed the available soil moisture should not be more than one-third depleted before the subsequent irrigation. For average years in the Magic Valley area of Idaho this would require approximately 8 irrigations. These irrigations should be timed to coincide with the consumptive use requirements of the crop. If soil moisture is high at the time of planting there will be sufficient available water in the soil for 25 or 30 days.

Regular irrigations should be started at about an 8-day interval. Maximum consumptive use occurs when the plants are 40-70 days old. During this period irrigations are required approximately every 6 days. Care should be taken not to over-irrigate and waterlog the soil, especially when irrigating at a 6-day interval.

Provided normal precautions are taken in handling seed and the plants are grown under an irrigation treatment which does not provide excess water, irrigation frequency appears to have no important effect on susceptibility to mechanical injury.

Irrigation of Snap Beans Grown For Seed in Idaho[1]

GALEN MCMASTER, MARSHALL LEBARON, G. L. COREY, LESLIE R. HAWTHORN, and VIVIAN K. TOOLE[2]

THE Magic Valley of Idaho is one of the major sources of snap bean seed in the United States. Low rainfall during the normal growing period makes irrigation a necessity for maximum seed production. Readily available irrigation water along with a dry climate makes this area ideal for seed bean production.

In earlier studies Myers *et al* (8) and Hawthorn and Pollard (5) found that bean and lettuce plants produced more seed when the soil moisture level in the root zone was not excessively depleted. Hawthorn (4), however, has also shown that carrots on deep, moist soils tend to produce high seed yield when the soil moisture is depleted to the wilting point in the top 2 feet of the root zone between irrigation applications.

Irrigation practices are largely determined by local climate, soil, topograpy, and crop being grown. Shallow-rooted plants such as beans require more frequent applications of water than deep-rooted ones. Research was necessary to determine the level of soil moisture in the root zone for maximum production of snap beans. It was important to study quality as well as total yield since irrigation practices might influence the susceptibility of the seed to thresher injury. The results of this research are presented in this bulletin.

Climate and Soil Conditions

The climate of the area is characterized by a low annual precipitation, a dry atmosphere, hot summers, and a large proportion of sunny days. Most of the annual precipitation occurs as rain or snow during the winter. The growing season is therefore comparatively dry. Table 1 gives the mean temperature and precipitation with departures from normal for the years of study.

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Table 1—Mean monthly summer temperature and precipitation and departures from normal at Twin Falls, Idaho.

	June		July		August		September	
	Mean	Departure	Mean	Departure	Mean	Departure	Mean	Departure
1956:								
Temperature (°F)	65.7	+2.6	73.6	+2.2	67.7	−1.0	62.2	+2.7
Precipitation (Inches)	0.20	−0.61	0.18	−0.17	Trace	−0.22	0.44	−0.13
1957:								
Temperature (°F)	65.0	+1.9	72.1	+0.7	70.9	+2.2	62.6	+3.1
Precipitation (Inches)	0.98	+0.17	0.22	−0.13	0.21	−0.01	0.06	−0.51
1958:								
Temperature (°F)	65.7	+2.6	72.1	+0.7	74.4	+5.7	62.4	+2.9
Precipitation (Inches)	0.62	−0.19	0.04	−0.31	0.15	−0.07	0.04	−0.53

A field on the Twin Falls Branch Experiment Station was utilized for this research. The plot soil was classified as Portneuf silt loam. This type of soil is characterized by a columnar structure from the surface to a depth of about 15 inches. Below this lies a compacted calcareous horizon which is fairly difficult to penetrate with a soil auger but is permeable to water. Before initial farming operation the top 2 or 3 inches consisted of a slightly coherent light brown desert mulch which has since lost its identity and become part of the top general horizon. The topography of the field was uniform with a slope of 1.25 percent in the direction of irrigation. Surface and sub-surface drainage was good and the field well adapted for an experiment involving irrigation.

Procedure

CULTURAL PRACTICES, IRRIGATION,AND HARVEST

The average planting date for the 2 varieties of snap beans used in this experiment, Topcrop and Wade, was May 27. Several days before planting, the field was irrigated to assure a uniform soil moisture level for all plots. Bean seed was planted at the rate of 120 pounds per acre in 22-inch rows. The field was cultivated only when necessary for weed control. After the initial cultivation the irrigation water supply, gated surface and plastic pipe, was laid to each replication. Each plot therefore received water independently. Three irrigation treatments were arranged in six replications. The replications were 113 feet long and 66 feet wide including buffer rows. Each irrigation plot was split to contain the 2 varieties. The seed was planted with a standard 4-row bean planter and 50 feet of the two middle rows of the sub-plots were harvested for yield. Six buffer rows separated the harvested rows.

The 3 irrigation treatments consisted of 3 frequencies of irrigation based on the amount of moisture in the soil at the time of application. The plants were irrigated when the available soil moisture had been 30 percent depleted, 60 percent depleted, and when the moisture level approached the wilting point. These treatments are described as "high soil moisture level," "medium soil moisture level," and "low soil moisture level." After each irrigation the soil moisture level was at field capacity regardless of the irrigation treatment. Furrows were made between all bean rows and water was applied in alternate furrows. The furrow receiving water was alternated at each subsequent irrigation (8).

The plants were cut with a standard 4-row bean cutter. In 1956 and 1958, the rate of maturity was sufficiently uniform to allow all plots to be cut on the same date. In 1957, however, the Topcrop variety was harvested before the Wade variety. Plants from the two 50-foot rows harvested for yield data were piled in small shocks and staked to the ground to prevent damage by wind. These shocks were threshed with a plot thresher after an 8-day field-curing period. Dirt and trash was removed from the threshed seed by cleaning in a Clipper cleaner. A separate portion of the yield rows was placed in a standard-sized windrow to field dry. Seed samples were taken throughout the entire cross-sectional area of this standard-sized windrow by hand picking and shelling pods until 400 grams of seed were obtained. These samples were later used for a seed injury study.

In 1955, a preliminary study was made on the Idaho Bountiful variety. This variety was compared with Topcrop and Wade for yield response to irrigation. In 1956 and 1957, a 6-inch spacing treatment was compared with the standard rate of planting (2-inch spacings in 22-inch rows). The 6-inch spacing was obtained by planting at a normal 2-inch interval and thinning to 6 inches immediately after emergence.

Since variety and spacing trials were being conducted by other departments of the Idaho Agricultural Experiment Station, the Idaho Bountiful variety and the 6-inch spacing treatment was discontinued in 1956.

SOIL MOISTURE AND CONSUMPTIVE USE DETERMINATION

Soil moisture samples were taken with a soil auger at planting time, before each irrigation, 24 hours after irrigation, and at harvest time for the purpose of determining soil moisture content and consumptive use under each irrigation treatment. Samples were also taken periodically between irrigations to determine when the available soil moisture in the root zone had depleted to the point requiring irrigation. Samples were taken from several locations in each plot. Approximately the same location was used for each sampling period. At each location samples were taken from the 0-6 inch depth, 6-12 inch depth, and 12-24 inch depth. The soil moisture content of the samples was determined gravimetrically.

The soil moisture percentage by weight was multiplied by the volume weight of the soil to convert to percentage moisture by volume. The amount of water consumptively used from the area of the root zone sampled was the difference in volumes of water in the samples between irrigation. The actual consumptive use measured between irrigations was extrapolated to include the consumptive use during the irrigation process.

Water in the soil that can be considered available for plant use exists between certain limits. These are the field capacity and the wilting point. Moisture in excess of field capacity is soon drained away by gravity and that below the wilting point is held too tightly by the soil particles to be available for plant use. Field capacity and wilting point vary for different soil texture, soil structure, salt content, root distribution, and weather conditions.

Field capacity is very difficult to determine accurately (2). For this study, field capacity was defined as the amount of moisture remaining in the soil following an irrigation and free drainage period of 24 hours. The average field capacity of the soil was found to be 22 percent water by weight. The wilting point was defined as the amount of moisture remaining in the soil when permanent plant wilting occurred. This limit was found to be 7 percent water by weight.

Because of the prevalence of Fusarium root rot in beans grown in the Twin Falls area the plants are very shallow-rooted (1, 7). Because of this disease, the majority of the roots are forced to feed in the top 6 inches of the soil. Such conditions increase the probability that crop yields will be increased when irrigations are applied to maintain a high soil moisture level (3).

SEED SIZING

In 1957 and 1958, the seed produced in this study was sized by screening a sample through a nest of screens. The sample for sizing was obtained from the seed threshed by the plot thresher. The screening was done after the seed had been stored for at least 6 weeks to insure uniform moisture content. The screens were of the standard round-hole type and arranged in the following order from top to bottom: 22/64″, 20/64″, 18/64″, 16/64″ screens, and pan. A 200-gram seed sample was tested, and the weight of seed held on each screen was recorded. A fineness modulus was determined by the following formula:

$$FM = \frac{a + b + c + d}{100}$$

where:

FM = fineness modulus

a = percentage weight held on top screen

b = percentage weight held on top 2 screens

c = percentage weight held on top 3 screens

d = percentage weight held on top 4 screens

MEASUREMENT OF POD THRESHABILITY

In 1958, a sample of 100 pods was taken from the windrows in all plots for tests on threshability. Pods were selected at random from the cross-sectional area of the windrows. All pods were given the same threshing treatment by running them between the rubber rollers of a plot thresher. The unthreshed pods in each plot were counted and a threshability index assigned which was numerically equal to the number of threshed pods in each sample tested. A high threshability index would indicate easily threshed pods.

ARTIFICIAL INJURY OF SEED

To adequately measure the susceptibility of seed to mechanical injury, particular emphasis was placed on the use of a special machine to simulate thresher injury. The artificial seed injury machine, developed by the Associated Seed Growers, was duplicated and used with the permission of Dr. Walter H. Pierce. The machine (Fig. 1) consisted of a metal box 12 inches long, 8 inches wide, and 12 inches deep. A cylinder 2 inches in diameter was mounted horizontally in the long axis of the box. Protruding angle irons were

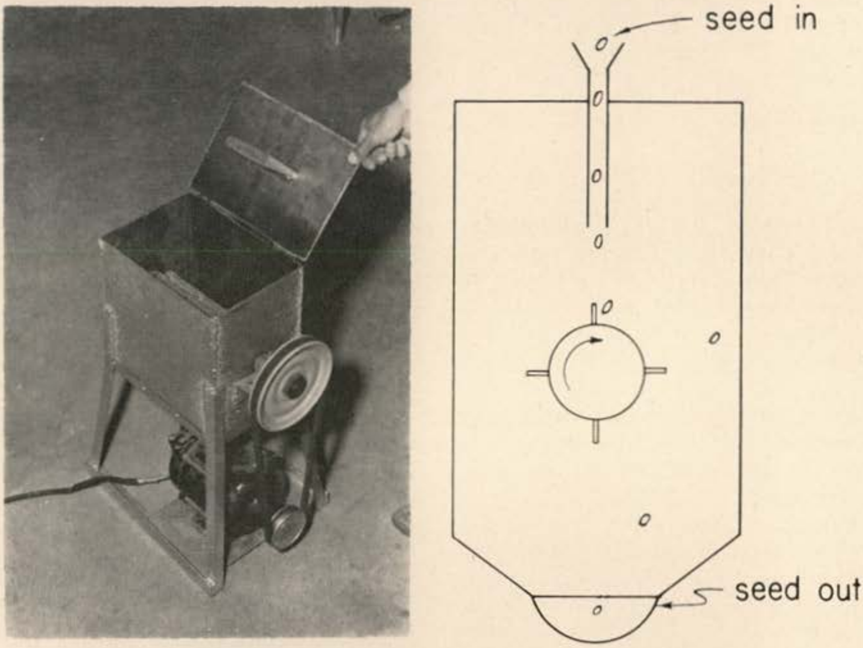

Figure 1. Left—Photograph of artificial bean seed injury machine developed by the Associated Seed Growers.
Right—Schematic cross-sectional drawing of the machine.

welded to the cylinder. The outer edges of these angle irons traveled at a peripheral speed of 10 feet per scond, approximately the same speed as the average combine cylinder used to thresh snap beans. The beans were fed through a slot in the top of the hinged door and allowed to drop on the rotating cylinder. Here they were struck by the revolving angle irons and thrown against the metal wall of the box; thus the artificial injury was produced. Since each seed was subjected to a blow, this machine gave a more uniform treatment of injury than the threshing operation.

Eight days after cutting, at which time there were no significant differences in the seed moisture content, a sample of seed was taken from the windrow of each plot and hand-shelled. The seed obtained was therefore presumably free from any mechanical injury. A portion of each sample was then subjected to a simulated threshing operation by the artificial injury machine. The treated seed and control were then shipped to Beltsville, Maryland, for germination tests. These were conducted in the Vegetable Seed Investigations Laboratory of the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture.

In 1956, the seed was shipped in bags in cardboard boxes without additional packing. In other years, the bags were padded to eliminate possible injury during shipment. On receipt, all seed was stored at 50° F. and 50 percent relative humidity so that changes would not occur during the short interval before testing.

GERMINATION METHODS AND EVALUATION OF SEEDLINGS

Germination tests were made on the 2 sub-lots of seed from each plot: one hand-shelled and free of mechanical injury and the other artificially injured. Germination tests were also made on the regularly threshed samples. One or two 100-seed samples were used from each field replication. These were planted, 100 seeds per flat, in a steam-sterilized muck and sand mixture in the greenhouse at a temperature of approximately 68° F. at night and 86° F. during the day.

After 2 weeks' growth, seedlings were pulled and classified for degree of mechanical injury. Detailed data were recorded, not only on the susceptibility of the seed to major damages that cause worthless seedlings, but also to less severe injuries that result in slight to moderate damage of the field-value seedlings. Previous studies (9) show that seed lots producing seedlings with slight to moderate damage deteriorate in storage more rapidly than those comparatively free of such minor injuries. A seed was considered to have germinated only if it produced a seedling capable of developing into a plant having field-value (a seedling capable of producing a normal plant under favorable conditions (10)). Within this field-value classification, the seedlings were further graded into those having no mechanical damage and those having slight to moderate mechanical damage. For example, of 100 seeds planted, 10 percent might fail to germinate or produce only very severely damaged seedlings and 90 percent would have field-value. Of this 90 percent, 75 percent may show no seedling defect and 15 percent may produce seedlings having slight to moderate mechanical injuries. The 90 percent (field-value) and the 15 percent with slight to moderate injuries are the types of values shown in the tables.

Experimental Results

SOIL MOISTURE AND CONSUMPTIVE USE

Data obtained from the oven-dried soil samples were used to determine irrigation frequency and seasonal consumptive use for the three treatments.

The total seasonal consumptive use and average daily consumptive use data during the peak use period for 1956, 1957, and 1958 are shown in table 2. Figure 2 shows the rate of accumulative consumptive use for the 3 irrigation treatments. The large difference in consumptive use under different irrigation treatments could be attributed to surface evaporation between irrigations (6). Each

Table 2—Irrigation and consumptive use data for Wade and Topcrop snap beans grown under 3 soil moisture levels at Twin Falls, Idaho.

Year and irrig. treatment	Number of[1] irrigations	Irrigation[2] interval	Consumptive use (inches)	
			Average daily[3]	Total seasonal
		(days)		
1956:				
High	8	8.0	0.26	13.78
Medium	4	16.3	0.21	8.52
Low	2	42.0	0.08	4.35
1957:				
High	9	5.8	0.27	12.68
Medium	6	9.4	0.26	12.99
Low	2	21.5	0.13	6.66
1958:				
High	10	6.8	0.20	13.87
Medium	6	10.5	0.22	10.85
Low	2	26.0	0.13	5.76
Average:				
High	9.0	6.9	0.24	13.38
Medium	5.3	12.1	0.23	10.79
Low	2.0	29.8	0.11	5.59

[1] Irrigation before planting not included.
[2] Average between successive irrigations during peak consumptive use period.
[3] Average during peak use period.

irrigation produced a wet soil surface giving a high evaporation opportunity; therefore the number of irrigations had an effect on consumptive use. The high moisture plots were irrigated an average of 9 times. The medium and low soil moisture treatments required 5 and 2 irrigations, respectively. In the high moisture treatment the plants used consumptively an average of 1.3 inches of water between irrigations. In the medium and low treatments the amount of water used between irrigations was 1.7 and 1.9 inches, respectively.

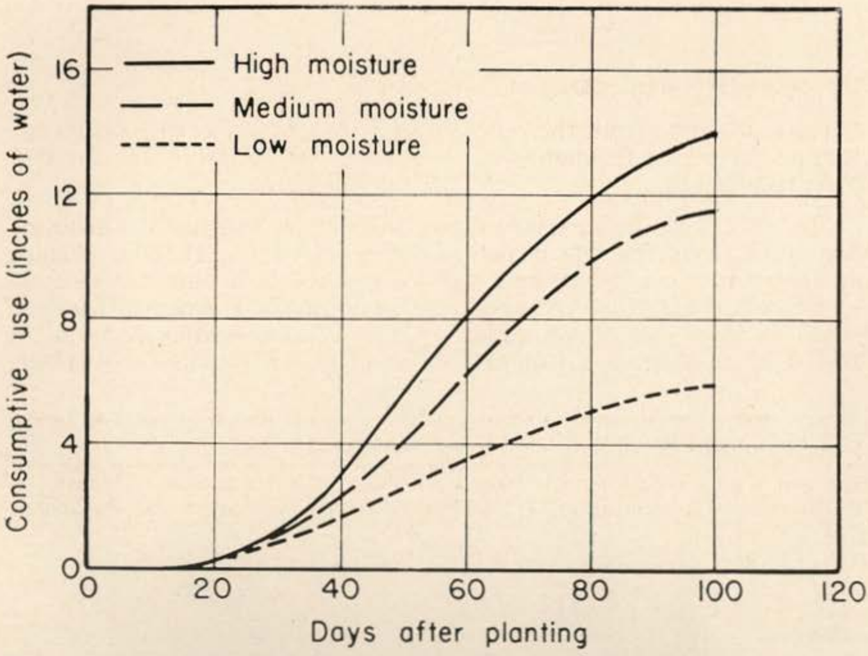

Figure 2. Seasonal accumulative consumptive use of water for snap beans grown at three soil moisture levels.

With this information and the curves from Figure 2, the irrigation interval for all periods of the growing season could be predicted with reasonable accuracy. Assume that the total available soil moisture in the root zone was equivalent to 3.5 inches of water and it was desirable to irrigate according to the high soil moisture treatment. A total of 1.4 inches (40 percent of the total available moisture) would be consumptively used between irrigations. The curve for the high moisture treatment (Fig. 2) indicates that 1.4 inches of water would be sufficient for approximately the first 30 days of the growing season. At the end of this period the soil should be irrigated until the 1.4 inches of water has been replaced. This amount of water would now last only 8 days. The irrigation interval will keep decreasing until it reaches a minimum value at approximately 55 days after planting.

The most frequent irrigations will occur at the point of maximum daily consumptive use during the hottest part of the growing season when the plants are developing most rapidly. Figure 2 indicates that the maximum daily consumptive use by snap beans grown under the high moisture treatment was 0.24 inch per day. During this period of peak use the irrigation interval would be 6 days. The period of maximum consumptive use extended from approximately 40 to 70 days after planting. The irrigation interval became longer as the end of the growing season approached.

Light, frequent irrigations were required to maintain a high soil moisture level. With surface irrigation it is difficult to apply a small quantity of water uniformly over a field without careful and exacting methods.

TOTAL YIELD

Total yield of Topcrop and Wade beans grown under the 3 irrigation treatments for 3 years is presented in Table 3. The irrigation practice which maintained a soil moisture level in the root zone at 60 percent field capacity or above resulted in the greatest yield

Table 3—Total clean seed yield (cwt/acre) of 2 varieties of snap bean seed as affected by 3 irrigation treatments in 1956, 1957, and 1958.

Year and variety	Soil moisture			
	High	Medium	Low	Average
1956:				
Topcrop	18.8	13.4	10.1	14.1 a[1]
Wade	19.1	14.6	10.9	14.9 a
1957:				
Topcrop	20.0	17.8	13.8	17.2 b
Wade	16.6	15.3	12.1	14.5 a
1958:				
Topcrop	21.3	21.1	15.2	19.2 c
Wade	20.9	20.8	15.6	19.1 b, c
Average	19.4 c	17.2 b	13.3 a	

[1] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test.

of seed for each variety. If the soil moisture level was allowed to drop to the vicinity of 30 percent of field capacity between irrigations, a substantial reduction in yield occurred.

Topcrop and Wade did not react the same to seasonal variations. In 1956 and 1958 the yields of the two varieties were similar. In 1957, however, the yield of Wade was considerably less than that of Topcrop.

In 1955, Topcrop, Idaho Bountiful, and Wade yielded 14.9, 15.5, and 17.4 hundred-weight per acre of cleaned seed, respectively. These data indicate that the yield of the Wade variety was significantly greater than that of Topcrop and of Idaho Bountiful. All 3 varieties, however, reacted the same to irrigation and spacing treatments during 1955.

The 2-inch plant spacing yielded significantly more than the 6-inch spacing in both years that the spacing trials were conducted. In 1956, the yield of the 6-inch spacing was 83 percent of the yield of the 2-inch spacing, and in 1957, 78 percent of the 2-inch spacing yield. No interaction between spacing and irrigation or spacing and variety occurred.

Figure 3 is a graph of the total yield plotted against the soil moisture content at the time of irrigation. Apparently the advantages gained in yield would have been small if the soil had been irrigated before the moisture level had dropped to 60 percent of field

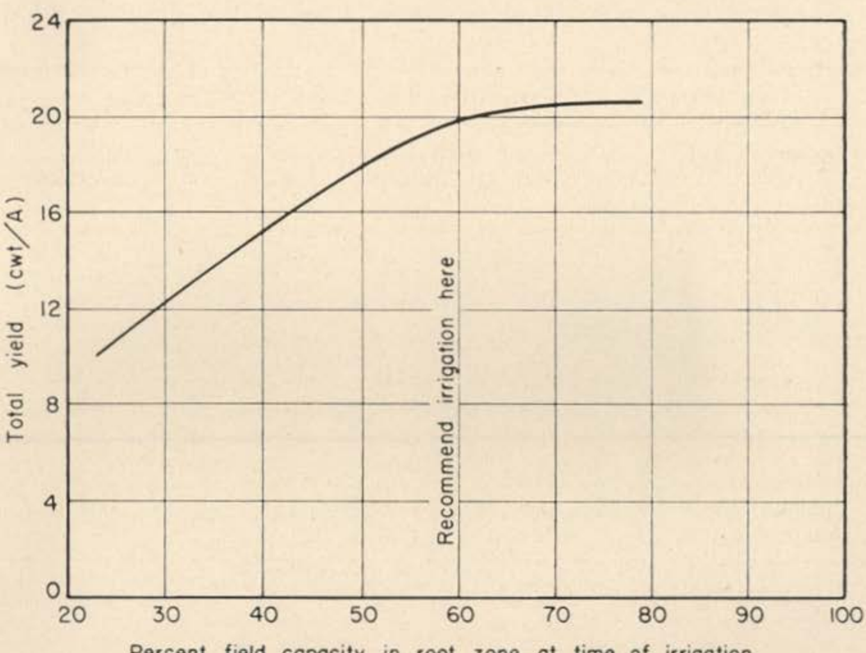

Figure 3. Total yield of snap bean seed as influenced by soil moisture content at time of irrigation.

capacity. When the soil moisture was allowed to drop below the 60 percent level the corresponding decrease in yield was relatively large. Water applied when the soil moisture had been depleted to the 60 percent availability level resulted in a satisfactory yield of seed without undue water or labor cost.

SEED SIZE

The varieties, Topcrop and Wade, normally produce small and large seed, respectively. The seed size of each was influenced by irrigation frequencies. The average fineness modulus for the seed from each treatment is shown in Table 4. The low soil moisture level produced the smallest seed and the medium soil moisture produced the largest.

Table 4—Average seed size[1] of 2 varieties of snap beans as affected by soil moisture and season.

Year and variety	Soil moisture level			
	High	Medium	Low	Average
1957:				
Topcrop	1.29	1.20	1.16	1.22 a[2]
Wade	1.72	1.84	1.70	1.76 c
1958:				
Topcrop	1.29	1.38	1.05	1.24 a
Wade	1.57	1.76	1.47	1.60 b
Average:	1.47 b	1.55 b	1.35 a	

[1] Fineness modulus, described in Methods; a large modulus indicates a large seed.

[2] Values followed by different letters are significantly different at the 1 percent level and those followd by the same letter are not significantly different on the basis of Duncan's multiple-range test.

THRESHABILITY OF PODS

Samples of unthreshed pods taken from all plots in 1958 indicated that the plants grown under the medium and low soil moisture levels were more easily threshed than those grown under the high moisture level. The average percentages of threshed pods for the three soil moisture levels were as follows: high 75.5; medium 81.2; and low 83.3. The least significant difference between treatments at the 5 percent level was 4.7. Moisture tests of seed in 1957 and 1958 indicated that the amounts of moisture contained at cutting and 8 days after cutting were not influenced by the soil moisture level during the growing season. The average moisture content of seed 8 days after cutting was 9.6 percent and that of the pod hull was 13.7 percent in 1958.

GERMINATION RESULTS

Through the several years of the experiments, a number of cultural practices in the production of the seed crop were tried without significantly influencing germinability of the seed or their susceptibility to thresher injury. The 2-inch and 6-inch spacings were included in the overall analysis for years when spacing was tested, but were found to be without significant effect. Similarly, the date of last irrigation for the 1 year tried, 1958, did not influence seed quality.

The differences in germination of hand-shelled and artificially injured seed were marked. The chief interest was in the interaction of these treatments with cultural practices and with variety. The results of the interaction of irrigation frequency during production and the susceptibility to mechanical seed injury are given in Table 5. In 1956 and 1957, when the degree of artifical injury was relatively slight, no relationship existed between irrigation frequency and major injury as shown by field-value. However, slight and moderate injuries tended to be proportional to the amount of water supplied, i. e., increased with increased water supply during the growing season. In 1958, when the degree of artificial injury was more severe, this same trend appeared in the field-value; the effect on slight and moderate injury is not so apparent. While the artificial injury machine provided a standard injury within any one year, the degree of injury varied from year to year.

Table 5—Interaction of treatment and soil moisture level on germination of Topcrop and Wade bean seed.

Year and treatment	Soil moisture level	Seed producing seedlings with Field-value	Seed producing seedlings with Slight to moderate mechanical injuries
		Percent	Percent
1956:			
Hand shelling	High	98 a[2]	4 a
	Medium	94 b	5 a
	Low	93 b	5 a
Threshing[1]	High	88 c	17 b
	Medium	87 c	14 c
	Low	89 c	11 d
1957:			
Hand shelling	High	96 a	3 a
	Medium	96 a	3 a
	Low	94 a	3 a
Artificial injury	High	88 b	16 b
	Medium	89 b	15 b
	Low	88 b	10 c
1958:			
Hand shelling	High	99 a	2 a
	Medium	99 a	3 a
	Low	99 a	2 a
Artificial injury	High	72 b	28 c, d
	Medium	77 c	30 c
	Low	80 d	25 b, d

[1] Threshed samples were used in 1956, for artificial seed injury machine was not available until 1957.

[2] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test. (11, p. 23)

The data in Table 5 were obtained by averaging the results from 2 varieties, Topcrop and Wade. However, these varieties did not react in the same way to irrigation frequency. Table 6 shows that

Wade was definitely more sensitive to injury at the high moisture level than at the low level; Topcrop shows little difference.

Table 6—Interaction of variety and irrigation frequency on germination of bean seed.[1]

Year and variety	Soil moisture level	Seed producing seedlings with Field-value	Slight to moderate mechanical injuries
		Percent	Percent
1955:			
Topcrop	High	76 a[2]	30 a
	Medium	77 a	26 a
Wade	High	83 a, b	26 a
	Medium	86 b	21 a
Idaho Bountiful	High	94 c	13 b
	Medium	95 c	11 b
1956:			
Topcrop	High	93 a	10 a, b
	Medium	90 a	12 a
	Low	93 a	9 b
Wade	High	93 a	11 b
	Medium	90 a, b	7 c
	Low	89 b	6 c
1957:			
Topcrop	High	94 a	8 a, b
	Medium	94 a	8 a, b
	Low	93 a	7 a, b
Wade	High	91 a	11 b
	Medium	91 a	9 a, b
	Low	89 a	7 a
1958:			
Topcrop	High	86 a	13 a
	Medium	87 a	19 b
	Low	88 a, b	14 a
Wade	High	85 a	17 a
	Medium	89 a, b	14 a
	Low	90 b	13 a

[1] The treatments within the analysis for each year are those given in table 5; in 1955, threshed samples only were used.

[2] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test. (11, p. 23)

The difference in the response of the 2 varieties to the artificial injury was significant only in 1957, when seed of Wade showed a significantly higher percentage of slight to moderate seeding damage than did Topcrop; 16 percent for Wade and 11 percent for Topcrop.

Prior to 1957, seed was cured in the field 8 days before being subjected to artificial injury. To check on the effect of time of curing on susceptibility to mechanical injury, 2 periods of curing (4 and 8 days) were tested in 1957. Seed cured 8 days were more susceptible to injury than those cured 4 days (Table 7).

Table 7—Effect of curing period on susceptibility of seed beans to mechanical injury as indicated by germination.

Period cured	Field value of seedlings from seed		Seedlings with slight to moderate injuries from seed	
	Hand shelled	Artificially injured	Hand shelled	Artificially injured
	Percent	Percent	Percent	Percent
4 days	97 a[1]	94 b	2 a	4 a
8 days	92 c	84 d	10 b	17 c

[1] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test. (11, p. 23)

Seed of the variety Wade were injured more severely after 8 days' curing than seed of Topcrop (Table 8).

Table 8—Effect of curing period on germination of 2 varieties of bean seed.

Period cured	Field value of seedlings of		Seedlings with slight to moderate injuries of	
	Topcrop	Wade	Topcrop	Wade
	Percent	Percent	Percent	Percent
4 days	95 a[1]	94 a	5 a	8 b, c
8 days	92 b	86 c	11 b	10 b

[1] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test. (11, p. 23)

Level of soil moisture was without significant effect on responses to time of curing in the field.

The percentage of field-value seedlings of the hand-shelled seed of variety Wade was significantly lower than that of Topcrop, but the losses of germination due to mechanical injury were about the same for both varieties. The percentage of seedlings with slight to moderate injury was significantly higher for Wade than for Topcrop (Table 9).

The results of the germination tests of the seed threshed with the plot thresher in 1957 and 1958 are not shown, but in both years the degree of injury produced by threshing was less than by artificial injury. The injury resulting from the plot thresher used is comparable with that from the better commercial bean threshers.

Table 9—Interaction of treatment and variety on seed cured 4 and 8 days as indicated by germination.

Treatment	Field value of seedlings of		Seedlings with slight to moderate injuries of	
	Topcrop	Wade	Topcrop	Wade
	Percent	Percent	Percent	Percent
Hand shelling	97 a[1]	94 b	4 a	2 a
Artificial injury	90 c	86 d	11 c	16 b

[1] Values followed by different letters are significantly different at the 1 percent level and those followed by the same letter are not significantly different on the basis of Duncan's multiple-range test. (11, p. 23)

The effects of soil moisture levels and varieties would therefore be less important in good commercial practice than are indicated by these results using the artificial injury machine.

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Summary

A project was initiated in 1955 to test the effect of soil moisture level on yield and quality of snap bean seed. Four years' results were obtained on 2 varieties. To maintain 3 different soil moisture levels in the root zone as selected 3 irrigation treatments were necessary. The moisture level was allowed to vary from field capacity (after irrigation) to approximately 30 percent, 60 percent, and 80 percent depletion (prior to the next irrigation).

The soil moisture level maintained in the root zone throughout the growing season probably had more effect on the total yield of snap bean seed than any other single cultural practice. Although the yield was found to decrease with a low soil moisture level, the seed produced by this treatment tended to be more resistant to mechanical injury. This effect was more pronounced with the Wade than with the Topcrop variety. However, the effect was not large and was created by an artificial injury machine which produced more severe damage than the plot thresher and probably more than good commercial harvesting procedures.

The results of the snap bean seed irrigation project can be summarized as follows:

1. Consumptive use was increased as the level at which the soil moisture was maintained increased. This was due to the increased opportunity for surface evaporation from the soil kept moist by frequent irrigation.
2. Maximum total yield was obtained from plants grown under a high soil moisture level (moisture varying from 100-60 percent of field capacity).
3. Irrigation before the available soil moisture had dropped to 60 percent of field capacity resulted in very little increase in yield and the economic return was doubtful.
4. Irrigation when soil moisture was 80 percent depleted resulted in smaller seed. This was especially true in the Wade variety.
5. Seed grown at the low moisture level was slightly less susceptible to mechanical injury than seed grown at higher moisture levels. This was especially true for the Wade variety. However, the magnitude of this effect was so small that it is of little commercial significance and is probably less important than the length of curing prior to threshing.

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