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TAXONOMIC VALUE OF CHARACTERS IN CULTIVATED BARLEY
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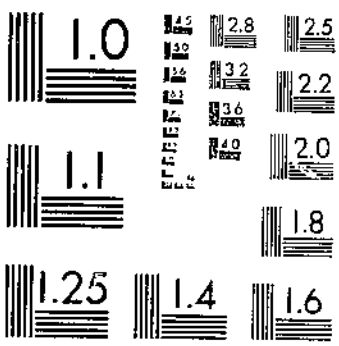

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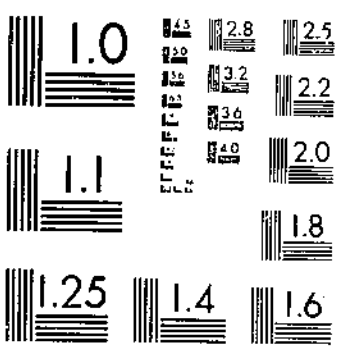

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Taxonomic Value of Characters in Cultivated Barley[1]

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INTRODUCTION

In taxonomic work with any plant, distinct and stable morphological characters are of the greatest usefulness. In the classification of varieties of cultivated plants, however, minute and less reliable mor-

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phological characters or physiological, genetic, and ecological characters also must be used in order to distinguish between similar varieties. Their use becomes even more essential as new varieties developed by plant breeders enter into cultivation.

PREVIOUS INVESTIGATION

Very little work has been done to determine the taxonomic value of various characters in cultivated barleys grown under distinctly different environmental conditions. One such investigation, however, planned with this objective and published by Harlan in 1914 (*12*),[3] has remained the outstanding work in this field. Harlan studied a series of varieties grown for 5 years at eight stations in Minnesota, North Dakota, South Dakota, Montana, Idaho, and California. He was concerned chiefly with characters useful for breeding improved varieties and made the following statement in his summary:

> While all lesser distinctions must be based upon the broader groups and no study of a cereal can omit its classification, the plant characters useful in taxonomic work and the ones most useful in plant breeding are far from being the same. Plant breeding is concerned with minute differences. The broad taxonomic divisions are serviceable only as groups. The problem of the nursery is not to separate a 6-rowed Manchuria from a 2-rowed Hanna barley, but to detect a variant in a plat of Manchuria.

This statement was true at the time it was made, when barley improvement consisted largely of selection within a variety. At present, however, it is recognized that there is no such clear-cut distinction between the use of plant characters. Many of the major morphological characters reflect differences in adaptation, technological use, or market value. The classification of cultivated barleys is now mainly a classification of plant-breeding products and therefore must be based in part on the same plant characters that are useful in plant breeding. This makes it necessary to deal with minute characters and to evaluate all taxonomic characters under varying environmental conditions before they are applied in a classification scheme. The studies described here are similar in many respects to the ones carried out by Harlan from 1909 to 1914.

An excellent study, somewhat similar to that reported here, has been made by Bergal and Friedberg (*8*) on the varieties commonly grown in France. This work was published in 1940, just prior to World War II, but a copy was not available to the writers until after the war and their own studies had been completed and submitted for publication.

TECHNIQUE USED IN PRESENT INVESTIGATION

The investigation here reported was undertaken in connection with a program of classification of cultivated barleys in the United States and Canada (*2*). It was begun in 1942 at Madison, Wis., where all the varieties listed in a bulletin summarizing the yields at experiment stations for the 5-year period 1937–41 (*19*) were grown for identification. During the winter 1942–43, studies on technique to be applied were carried on, and some of the results of these studies are reported.

[3] Italic numbers in parentheses refer to Literature Cited, p. 73.

The field studies were extended in 1943 and 1944, when nurseries of winter and spring barleys were grown. A total of 69 winter varieties and 119 spring varieties were studied. These were grown at 13 stations in the United States and 2 in Canada (fig. 1), selected to represent typical areas of barley production and to include a wide range of environment.

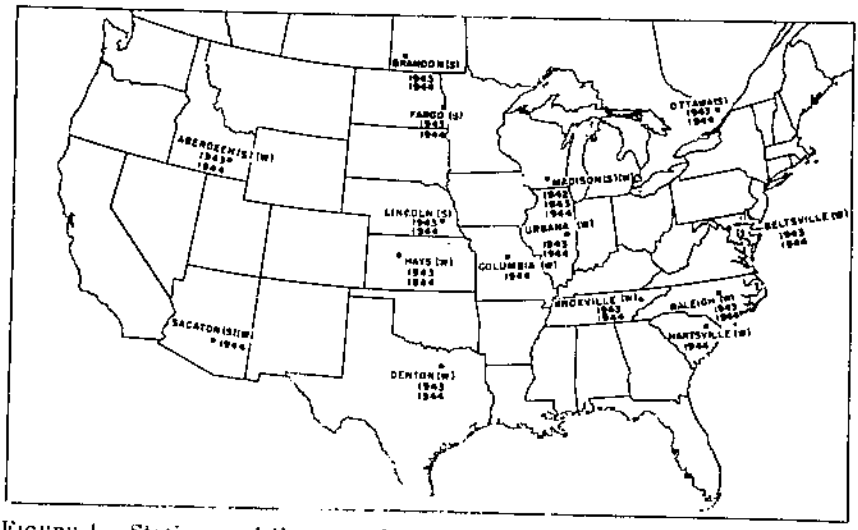

FIGURE 1.—Stations and the years during which the barley varieties were grown for classification studies. S=Spring varieties; W=winter varieties.

Extensive notes were taken in the field during the growing season and, later, in the laboratory on spike specimens. All the winter varieties were six-rowed (*Hordeum vulgare* L. emend. Lam.), while 100 of the spring sorts were six-rowed and 19 two-rowed (*Hordeum distichum* L. emend. Lam.). The varieties were planted in plots of two 5-foot rows or in single 10-foot rows. At most places a single seeding was made; but at some, two were made on different dates in order to extend the scope of the studies. At harvest, about 15 spikes were collected from each variety and used for measurements and for such detailed observations as could be made more easily in the laboratory. In all, 240 items were noted on each spring variety and 320 on each winter variety, or a total of approximately 53,000 recorded observations for all varieties. The winter varieties were grown from fall and spring seedings and from vernalized and nonvernalized seed, in order to evaluate the winter growth habit of each.

Each character is discussed in the text, and in addition all characters are classified or grouped in tables. In each detailed table the varieties are classed by groups and are given reference numbers for use in the summary tables, in which all varieties are listed by name. The variety listed under the group number in the detailed table is a typical representative of the varieties belonging to that group. The distribution of the varieties among the groups with respect to a character also indicates its value for classifying a large number of varieties.

CLIMATIC CONDITIONS

The general climatic conditions at the location where the nurseries were grown are given in table 1. The climatological data for the nurseries in the United States are from the United States Weather Bureau; those for Ottawa, Ontario, Canada, from the Cereal Division, Central Experimental Farm at Ottawa; and those for Brandon, Manitoba, Canada, from the Experimental Farm at Brandon.

FACTORS DETERMINING THE VALUE OF TAXONOMIC CHARACTERS

The most important qualification for the taxonomic value of a character is that it be constant under all environments. No character can be used satisfactorily for the main divisions of a taxonomic scheme without this qualification, and its value becomes less as its stability decreases. Even then its usefulness is limited, unless the character divides the material into major groups, making it possible to use several other characters for further divisions. The separation of six-rowed and two-rowed barleys is, for example, based on a stable character dividing the material into 2 large groups. Should a character separate only 1 variety from 100 others its usefulness is limited. Thus, Ezond is the only variety among 188 having fully smooth glume awns. Again, the separation based on anthocyanin in different parts of the plant is difficult, owing to the variability of the character, and furthermore only small groups can be separated from the large mass of material that is intermediate in character.

The value of a taxonomic character is also determined by the ease with which it can be seen or recognized. The six-rowed or two-rowed character can be determined at a glance. Minute characters that are hard to see or find are of much less value. Varieties can be separated on the length of the rachis internode, but in order to do this it often is necessary to make a number of time-consuming physical measurements.

Characters that are transient or temporary are not as valuable as those that are more permanent. Anthocyanin colors in the auricles and awns are usually expressed for only a short period. On the other hand, the length of rachilla hairs persists indefinitely from the time they are formed.

Spike and kernel characters have an added advantage over other plant characters for identification in that they often are the only ones available for this purpose, for it is a common practice to give the taxonomist a few spikes or some threshed seed when an identification is needed.

Varieties developed by plant-breeding often show a greater variability in some of their characters than do the older introduced varieties. In many cases these variations are quite constant from one generation to another, even when grown under varying environmental conditions; for example, the hairs on the glumes of a variety either cover the glumes, are arranged in bands, or are restricted to the midline. This is typical for the variety, but it is a difficult character to evaluate. It is stable, yet it is necessary to establish whether or not the mixture is a mechanical one or is an inherited varietal character.

TABLE 1.—*General climatic conditions for the locations where the nurseries were grown*

Station	Year	Latitude	Elevation	Approximate growing season	Weather during growing season				
					Range of mean temperatures	Precipitation	Clear days	Partly cloudy days	Cloudy days
		Degrees	*Feet*		° *F.*	*Inches*	*Percent*	*Percent*	*Percent*
Spring area:									
Aberdeen, Idaho	1943	43	4,400	April to July	51-70	2.9	54.9	30.3	14.8
Do	1944	43	4,400	do	43-67	5.5	47.5	25.4	27.1
Brandon, Manitoba, Canada	1943	50	1,220	May to August	47-69	10.0	15.4	52.9	31.7
Do	1944	50	1,220	do	56-65	16.7	18.7	35.8	45.5
Fargo, N. Dak	1943	47	895	May to July	51-73	11.8	30.4	32.6	37.0
Do	1944	47	895	do	59-69	15.0	19.6	46.7	33.7
Lincoln, Nebr	1943	41	1,180	April to mid-July	54-79	9.8	26.4	39.2	43.4
Do	1944	41	1,180	do	46-78	20.5	25.5	46.5	34.0
Madison, Wis	1943	43	974	May to July	55-74	9.5	15.2	44.6	40.2
Do	1944	43	974	do	62-72	13.5	15.2	51.1	33.7
Ottawa, Ontario, Canada	1943	45	270	May to August	54-69	21.6	(1)	(1)	(1)
Do	1944	45	270	do	60-70	7.0	(1)	(1)	(1)
Winter area:									
Beltsville, Md.[2]	1942-43	39	160	October to June	33-78	35.2	31.9	32.6	35.5
Do	1943-44	39	160	do	36-74	29.0	36.9	33.2	29.9
Columbia, Mo	1943-44	39	739	do	29-78	29.0	32.1	32.8	35.1
Denton, Tex	1942-43	33	621	October to May	46-73	22.6	50.6	23.0	26.4
Do	1943-44	33	621	do	45-71	28.1	49.2	25.4	25.4
Hartsville, S. C.[3]	1943-44	34	175	Mid-October to mid-May	43-72	24.9	44.1	33.8	22.1
Hays, Kans.	1942-43	39	2,000	October to mid-June	32-77	9.2	36.8	41.9	21.3
Do	1943-44	39	2,000	do	30-76	15.1	34.0	36.2	29.8
Knoxville, Tenn	1942-43	36	980	do	39-80	30.4	30.2	40.3	29.5
Do	1943-44	36	980	do	40-79	31.0	31.4	30.6	38.0
Raleigh, N. C	1942-43	36	343	October to May	41-71	28.4	35.4	23.0	41.6
Do	1943-44	36	343	do	44-79	29.6	40.6	28.3	31.1
Urbana, Ill	1942-43	40	743	do	25-75	32.9	42.1	12.1	45.8
Do	1943-44	40	743	do	28-76	31.9	49.3	8.4	42.3
Spring or winter area:									
Sacaton, Ariz	1943-44	33	1,280	November to mid-May	40-72	6.6	67.1	17.0	16.9

[1] No data on clear, partly cloudy, and cloudy days were available. The average hours of sunshine, per day, during the 1943 growing season were 8.0 and during the 1944 growing season, 8.6.

[2] Observations made at College Park, Md.

[3] Observations made at Darlington, S. C.

In the circumstances exemplified, it seems desirable to know what peculiarities are associated with different characters and what taxonomic value each character has, before an attempt is made to classify a group of varieties.

CHARACTERS STUDIED

A great many characters were studied, and from the observations made they were placed in two groups, those useful and those not useful for taxonomic work. The value of a particular character might be changed materially if a group of varieties of more diverse origin were studied. The characters falling into the two groups are listed below, but only those in the useful group are discussed and illustrated.

Characters useful in taxonomic work:
- Growth characters:
  - Spring or winter growth habit
  - Early growth
  - Time of heading
  - Postharvest seed dormancy
- Leaf characters:
  - Hairiness of leaf sheaths
  - Color of leaves
  - Length and width of leaves
  - Anthocyanin in leaf sheaths and auricles
  - Waxiness of leaf sheaths and leaves
  - Position of leaves before heading date
  - Size and shape of flagleaves
  - Curling of flagleaves
- Stem characters:
  - Height of plants
  - Strength of straw
  - Number of exposed nodes
  - Anthocyanin in nodes
  - Anthocyanin in stems
  - Shape of neck
  - Distance from flagleaf to spike
  - Shape of collar
- Spike characters:
  - Number of rows in spike
  - Shape of spike
  - Length of spike
  - Waxiness of spike
  - Spike density
  - Tweaked spike
  - Number of sterile spikelets at base of spike
  - Overlapping of lateral kernels
  - Position of spike
  - Toughness and brittleness of rachis
  - Hairiness of rachis edges

Characters useful—Continued
- Spike characters—Continued
  - Length of basal rachis internode
  - Shape of rachis internode
  - Glumes
  - Glume length
  - Hairiness of glumes
  - Length of glume awns
  - Barbing of glume awns
  - Length of awns
  - Barbing of awns
  - Deciduous awns
  - Anthocyanin in glume awns and awns
  - Hood contrasted with awns
  - Elevation of hoods
  - Hood appendages on middle lobe
  - Length of stamens
  - Hairiness of stigma
  - Threshability and shattering
- Kernel characters:
  - Naked contrasted with covered kernels
  - Kernel length
  - Germ length
  - Shape of kernels
  - Lemma-base shape
  - Lemma teeth and hairs
  - Wrinkling of hulls
  - Rachilla hairs
  - Rachilla abortions
  - Length of rachilla
  - Kernel colors
  - Color of lemma and palea
  - Color of caryopsis
  - Color of aleurone
  - Width of depth of ventral crease
  - Kernel weight

Characters not useful in taxonomic work:
- Leaf characters:
  - Size and shape of auricle and ligules
  - Roughness of leaves
  - Number of stem leaves
- Stem character:
  - Hairiness of nodes
- Spike characters:
  - Rachillate lateral kernels
  - Shape of rachis and rachis internodes
- Characters not useful—Continued
  - Spike characters—Continued
    - Distance between glumes at point of attachment
    - Glume width
    - Width of awn at tip of lemma
    - Deciduous lemma
    - Size of middle lobe of hood
  - Kernel character:
    - Width of point of attachment of kernels

GROWTH CHARACTERS

Spring or Winter Growth Habit

The classification of a variety according to spring or winter growth habit is best made on the basis of its usage and on the presence, or absence, of a rosette-growth stage between germination and the time the stems elongate. In spring varieties the rosette stage is lacking or nearly so, whereas in winter varieties it is a significant stage in the life of the plant. All spring varieties head readily from spring seeding, whereas winter varieties treated similarly may or may not head; and the extent of heading is closely associated with the degree to which the rosette stage is expressed. A weak rosette stage is followed by a great deal of heading, and conversely, a strong rosette stage by little if any heading.

The growth-type reaction of winter varieties was studied in several ways: (1) By observations in the field of fall seedings made in the winter barley area; (2) by observations of the extent of heading from spring seeding in the spring barley area; and (3) by observations on the effects of vernalization.

The observations according to (1) and (2) above are given in tables 2 and 3, respectively. The characteristic growth-type reaction is shown for each variety when seeded in fall and in spring. The notes on the fall-sown material were taken on the length of duration of the rosette-growth period and the speed of development before heading; whereas the notes on the spring-seeded material are on the percentage of plants that headed or failed to head. Thus, in group 3, for example, of table 3 and at Aberdeen, Idaho, on June 28, 1944, 10 percent of the plants of Marnobarb were classified as having a winter-growth type, whereas 90 percent had a spring-growth type.

The vernalized seed, fall-seeded at Sacaton, Ariz., in 1943, was treated at 33° to 34° F. for 30 days, and that spring-seeded at Aberdeen, Idaho, in 1944 was treated at the same temperature for 38 days. The vernalized and nonvernalized seed of each variety was grown in adjacent rows. It was evident that vernalization reduced the germinating capacity of the seed and produced slightly poorer average stands than the untreated seed. The difference between the two, however,

was slight and did not affect other observations that were made. Table 4 gives the dates when plants from vernalized and nonvernalized seed first showed differences in the rate of development and when each headed and ripened. It is evident from tables 2, 3, and 4 that the winter barleys have a rather wide range of response to environment and to vernalization.

FIGURE 2.—Effect of vernalization on *A* Nakano Wase, and *B* Purdue 28156 A3–2–2–2: *a*, Nonvernalized; *b*, vernalized. Sacaton, Ariz., January 12, 1944.

The effect of vernalization on two varieties of barley is shown in figure 2. Nakano Wase responded quickly to vernalization, whereas Purdue 28156 A3–2–2–2 gave only a weak response. The latter variety is classed with the Reno group in table 4.

TABLE 2.—*Growth-type reaction of 69 winter varieties when fall-seeded*

[W, Winter; SW, intermediate between spring and winter; and S, spring type]

Station	Year	Group 1: Nakano Wase	Group 2: Wong	Group 3: Marnobarb	Group 4: Iredell	Group 5: Reno, Tenkow, Winter Club
Raleigh	1942–43	SW	SW	SW	W	W
Do	1943–44	S	SW	W	W	W
Hartsville	1943–44	SW	SW	SW	SW	W
Varieties represented, number		1	6	5	25	32

TABLE 3.—*Growth-type reaction of 69 winter varieties when spring-seeded*

[W, Winter; SW, intermediate between spring and winter; and S, spring type; preceded by percentage figures]

Station	Date	Group 1: Nakano Wase	Group 2: Wong	Group 3: Marnobarb	Group 4: Iredell	Group 5: Reno	Group 6: Tenkow	Group 7: Winter Club
Madison	June 25, 1943	100W	100W	50W 50S	100S	100W	100S	100SW
Do	July 29, 1943	100W	100W	40W 60S	2W 98S	90W 10	100S	100SW
Do	Aug. 3, 1943	100W	100W	35W 65S	2W 98S	97W 3S	100S	100SW
Do	July 7, 1944	100W	100W	75W 25S	20W 80S	100W	100S	100S
Aberdeen	June 28, 1944	100S	100W	10W 90S	100S	50W 50S	100S	100SW
Do	End of July 1944 [2]	100S	10W 90S	2W 98S	100S	1W 99S	100S	100S
Varieties represented, number		3	1	8	6	31	18	2

[1] Trace of spring type.
[2] This observation was made on the ripening dates of the varieties

Such varieties as Reno, Tenkow, and Winter Club, which have a typical winter-growth type, give the poorest response to vernalization. This is to be expected, as the amount of vernalization applied was not intended to break a long-winter rosette stage. It will be noted in table 3 that the Reno group has more winterness than the Winter Club or Tenkow groups. It is also evident that the Wong group, which does not show the typical winter growth in North Carolina and South Carolina, but rather the intermediate growth, reacts as a winter type when vernalized and grown from spring seeding. Nakano Wase seems to be unpredictable in its reactions, both when fall-seeded in the Southeastern States and when spring-seeded in the Northern States, and yet there is no doubt that its winterness is more easily broken by vernalization than that of any other variety. The intermediate group, represented by Marnobarb and Iredell, seems to be more uncertain in its reactions than any other group, but the fact that it remains intermediate in all places probably indicates that genetic and environmental influences are about equally balanced.

These findings confirm the earlier statement that there is no more satisfactory way of grouping cultivated barleys into spring or winter

TABLE 4.—*Reaction of 69 winter varieties to vernalization*

Station, year, and treatments	Group 1: Nakano Wase	Group 2: Wong	Group 3: Marnobarb	Group 4: Iredell	Group 5: Reno	Group 6: Tenkow	Group 7: Winter Club
Saeaton, 1943–44:[1]							
Date vernalized rows showed faster development than nonvernalized	Dec. 28	----------	Jan. 1–Feb. 7	Jan. 1–Feb. 7	Feb. 8–Mar. 13	Feb. 8–Mar. 13	----------
Heading date:							
Vernalized	Feb. 5	Mar. 26	Mar. 18	Mar. 26	Mar. 26	Apr. 1	Apr. 12.
Nonvernalized	Mar. 18	do	Mar. 27	Mar. 31	Apr. 7	Apr. 6	Apr. 16.
Ripening date:							
Vernalized	Apr. 12	Apr. 27	May 1	Apr. 24	May 4	May 12	May 20.
Nonvernalized	Apr. 20	do	May 3	do	May 16	May 16	Do.
Aberdeen, 1944:[2]							
Heading date:							
Vernalized	June 15	June 30	June 20	June 25	June 20	June 21	July 2.
Nonvernalized	June 21	July 10	do	do	June 27	June 23	July 4.
Ripening date:							
Vernalized	July 24	July 31	July 24	July 22	July 28	July 28	Aug. 4.
Nonvernalized	do	Aug. 6	July 26	do	Aug. 1	do	Aug. 5.
Varieties represented number	1	2	13	20	17	8	8

[1] Seeded Nov. 9, 1943.

[2] Seeded Apr. 8, 1944.

types than that based on common usage. The information used in arriving at such a grouping has accumulated over a period of many years and under a greater range of conditions than any short-time experiment as reported here can produce. It also is evident that genetically the winter- or spring-type character must be based on a large number of factors.

Early Growth

While the classification into spring and winter growth habit is based on common usage, on differences in rosette-growth stage, on the ability to head after late-spring seeding, and on the reaction to vernalization, the grouping in relation to early-growth type is based on the manner in which the leaves are held during the six- to eight-leaf stage before the stems start to develop. The leaves can be erect, semiprostrate, or prostrate.

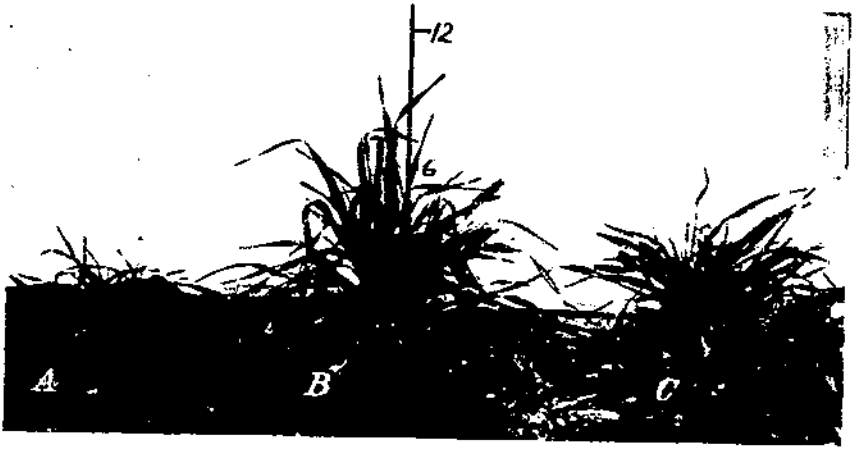

Figure 3.—Barley growth types: *A*, Prostrate; *B*, erect; *C*, semiprostrate.

The early growth was observed at two places, Sacaton and Madison. The results are given in table 5, and the three types of growth are shown in figure 3.

The observations from the two stations are very different. A better differentiation of the early growth was obtained in Sacaton, as some spring barleys that did not show any tendency to prostrate growth under Madison conditions did so at Sacaton (table 5). The early-growth behavior was more typical for spring barley at Madison, however, than at Sacaton.

In winter barley the comparisons are based on observations from spring-seeded material at Madison and fall-seeded at Sacaton. Conditions at Madison are abnormal for winter barley, and this seems to force most of the varieties into a kind of prostrate growth. Prostrate growth is not so common when the same varieties are grown under more normal winter barley growing conditions, as at Sacaton. The Sacaton observations are, therefore, most likely to be typical for winter barley. The variations in early growth, as caused by location and seeding time, are shown in table 5.

TABLE 5.—*Growth habit*

[E, Erect; Sp, semiprostrate; P, prostrate]

SPRING VARIETIES (119)

Station	Year	Group 1: Atlas	Group 2: Tanis	Group 3: Rojo	Group 4: Vaughn	Group 5
Madison	1943	E	E	E	E	
Sacaton	1943–44	E	E to Sp	Sp	Sp to P	
Varieties represented, number		74	26	14	5	

WINTER VARIETIES (69)

Station	Year	Esaw	Marnobarb	Tennessee Winter (C. I. 257)	Purdue 28154 A3-1-1-6	Purdue 28156 A3-2 2-2
Madison	1943	Sp	E to Sp	Sp to P	P	P
Do	1944	P	E to Sp	Sp to P	P	P
Sacaton	1943–44	E	E to Sp	Sp	Sp to P	P
Varieties represented, number		4	18	24	22	1

[1] C. I. in this and subsequent tables refers to accession number of the Division of Cereal Crops and Diseases.

TABLE 6.—*Grouping according to time of heading*

[E, Early; M, midseason; L, late]

SPRING VARIETIES (119)

Station	Year	Group 1 (early): Flynn	Group 2 (early to midseason); Mars	Group 3 (midseason): O. A. C. 21	Group 4 (midseason to late): Wisconsin Barbless	Group 5 (late): Plush
Madison	1943	E	M	M	L	L
Do	1944	E	E	M	L	L
Fargo	1943	E	E	E	L	L
Do	1944	E	E	M	M	L
Lincoln	1943	E	E	M	L	L
Do	1944	E	M	M	M	L
Aberdeen	1943	E	E	E	M	M
Do	1944	E	E	L	M	L
Sacaton	1943–44	M	E	M	L	L
Brandon	1943	E	M	M	M	L
Do	1944	E	E	M	M	L
Ottawa	1943	E	M	M	L	L
Do	1944	E	M	M	L	L
Varieties represented, number		30	20	21	27	18

WINTER VARIETIES (69)

Station	Year	Tennessee Winter (C. I. 257)	Wisconsin Winter	Admire	Purdue 21	Olympia
Raleigh	1942–43	E	E	M	L	L
Do	1943–44	E	M	L	L	L
Harrisville	1943–44	E	E	M	M	L
Knoxville	1942–43	M	E	M	L	L
Do	1943–44	E	E	M	M	L
Beltsville	1942–43	E	E	M	L	L
Do	1943–44	E	E	M	L	M
Urbana	1943–44	E	M	M	M	L
Columbia	1943–44	E	E	M	M	L
Hays	1942–43	E	E	M	M	L
Do	1943–44	E	E	M	M	
Denton	1942–43	E	M	E	L	L
Do	1943–44	E	M	M	L	L
Sacaton	1943–44	E	M	L	L	L
Aberdeen	1944					
Varieties represented, number		8	24	13	21	3

It appears from the data in table 5 that although early growth habit is a heritable character, its taxonomic value is lessened because of the great influence of environment on its expression.

Time of Heading

Time of heading, as used here, refers to the time of emergence of the awns or, in the case of hooded or awnless varieties, to the time the boot opens at the side. A number of ways of determining the heading date are in use, but all aim at one thing—the date when the spikes are flowering. The writers feel that the date of awn emergence or the opening of the boot most nearly coincides with flowering time when a large number of varieties are under study. These growth stages are definite events and insure accuracy in the results. This observation also has the advantage of being recorded at most stations before the onset of hot, dry weather, which can modify plant development.

Notes on time of heading were obtained at several stations during 1943 and 1944. The spring and the winter barleys are placed in five groups, according to time of heading as shown in table 6, and a typical variety has been chosen to represent each group.

The data indicate very definitely the usefulness of the character in classification work. They also show that widely differing groups can be distinguished easily, but that environmental influence must be considered when varieties of the same general maturity are to be separated. In these cases repeated observations at the same station and at different stations are needed for a safe grouping.

Postharvest Seed Dormancy

Unfortunately, it was possible to test the dormancy of freshly harvested seed at only one station, Aberdeen, and during only 1 year, 1944 (table 7). The data give an indication as to differences in seed dormancy among the varieties. In both spring and winter

Table 7.—*Postharvest seed dormancy in varieties grown at Aberdeen, Idaho, in 1944*

[Figures are percentage of germinated seeds]

SPRING VARIETIES (110)

Time after harvest for germination test	Group 1: Olli	Group 2: Wisconsin Barbless	Group 3: Manchuria (C. I. 7151)	Group 4: Flynn
2 weeks	100	22	3	0
1 month	100	81	45	0
2 months	100	100	82	16
Varieties represented number	4	95	14	6

WINTER VARIETIES (89)

Time after harvest for germination test	Kentucky 1	Randolph	Marett Awnless 1
2 weeks	37	7	0
1 month	95	29	4
2 months	100	80	33
Varieties represented number	51	13	5

barleys the most common group is that in which the seeds have some dormancy during the first month after harvest but lose it soon thereafter. About 70 percent of the varieties belong to this group. Only 2 percent have no dormancy at all, 11 percent have dormancy that lasts for 2 months or more, and 17 percent gradually lose their dormancy during the first 2 months after harvest.

LEAF CHARACTERS

Hairiness of Leaf Sheaths

The presence or absence of hairs on the leaf sheaths is a stable character in all environments, but is sometimes hard to use because observations have to be made during the early stages of plant growth. The basal leaf sheaths are more densely haired than the upper sheaths, which may or may not have hairs. Strikingly hairy types, as Belford, may be found, but the most common are the sparsely hairy and the nonhairy types. There also are some varieties that have two kinds of plants, those with hairy and those without hairy leaf sheaths. Such varieties probably originated as mixtures or as selections from

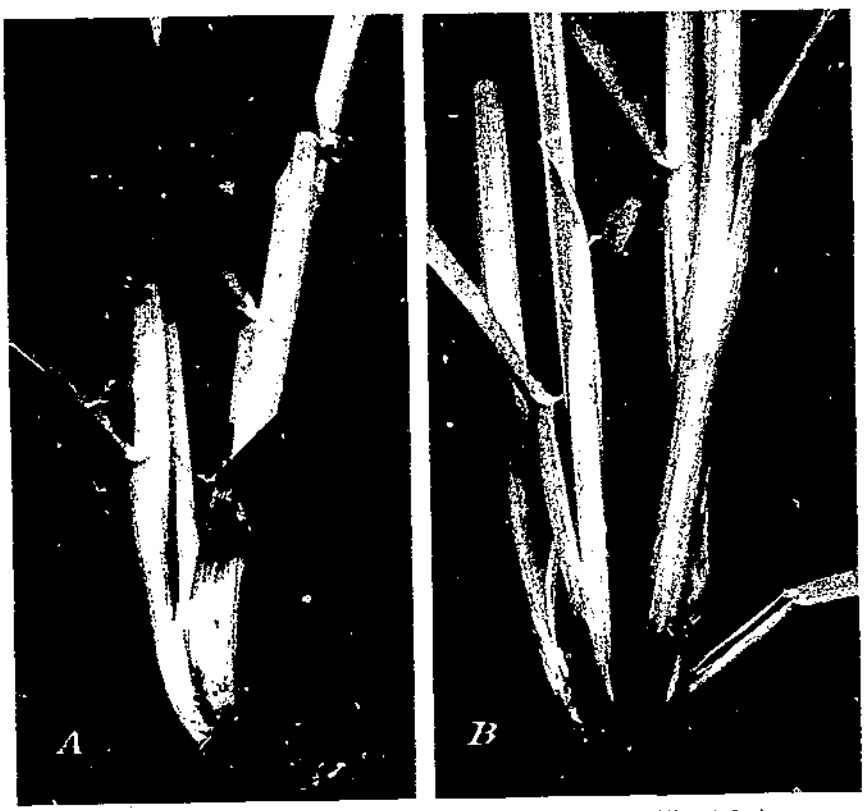

FIGURE 4.—Hairiness of leaf sheaths: *A*, Hairy; *B*, without hairs.

heterozygous hybrid material. Hairy and nonhairy leaf sheaths are shown in figure 4.

The varieties studied are placed in three groups, as shown in table 8. It will be noted that nonhairy leaf sheaths occur much more frequently among the spring barleys; 10 nonhairy types occur to 1 that is hairy, whereas among the winter barleys the 2 types are about equally common. The number of varieties having both hairy and nonhairy sheaths is small among both winter and spring varieties.

TABLE 8.—*Presence or absence of hairs on basal leaf sheaths*

[H, Hairs present; NH, hairs absent]

SPRING VARIETIES (110)

Station	Year	Group 1 (present): Duplex	Group 2 (present or absent): Common Six-Row (C. I. 4625)	Group 3 (absent): Velvet
Madison	1943	H	NH or H	NH
Sacaton	1943–44	H	H	NH
Varieties represented..... number..		11	3	105

WINTER VARIETIES (39)

Station	Year	Awnless	Esaw	Winter Club
Beltsville	1942–43	H	H	NH
Sacaton	1943–44	H	NH or H	NH
Varieties represented..... number..		30	5	34

COLOR OF LEAVES

Color of leaves is an unreliable character, as only small differences in shades of green exist among the varieties studied. Nutrition, location, soil, temperature, light, and other factors are more important in most cases than genetic factors in determining the shade of color. This is shown when notes taken on the same material but in different localities and at different times are compared. This lack of consistency in reaction is shown in table 9, and only in very extreme cases would this character be considered useful for taxonomic purposes.

TABLE 9.—*Observations on color of leaves*

[BG, Bluish green; DG, dark green; G, green; LG, light green]

SPRING VARIETIES (110)

Station	Year	Group 1: Perth	Group 2: Atlas	Group 3: Odessa	Group 4: Gulore	Group 5: Tall Comfort	Group 6: Composita	Group 7: Chevron	Group 8: Wisconsin Barbless
Madison	1943	DG	DG	DG	DG	G	LG	LG	LG
Sacaton	1943–44	DG	G	DG	G	G	G	DG	G
Aberdeen	1944	BG	BG	G	G	G	BG	LG	LG
Varieties represented..number..		7	19	4	42	22	9	2	14

TABLE 9.—*Observations on color of leaves*—Continued

WINTER VARIETIES (69)

Station	Year	Group 1: Brugh 76	Group 2: Tucker	Group 3: David-son	Group 4: Ten-nessee Beard-less 6	Group 5: Cascade	Group 6: Nakano Wase	Group 7: Wong	Group 8: Ten-nessee Beard-less 5
Madison	1943	DG	DG	DG	DG	G	LG	DG	DG
Sacaton	1943-44	BG	G	G	G	G	BG	LG	G
Aberdeen	1944	BG	BG	DG	G	G	DG	LG	LG
Varieties represented number		2	5	32	17	5	5	1	2

LENGTH AND WIDTH OF LEAVES

Both length and width of leaves are highly variable, and therefore they can be used successfully in taxonomy only when extreme differences exist. These characters vary with locality, and the influence of environment seems to be stronger than the influence of genetic factors. The data in tables 10 and 11 support these statements. All observations refer to spring varieties, as there were no noticeable differences among the winter varieties.

TABLE 10.—*Length of leaves in 119 spring varieties*

[L, Long; M, medium long; S, short]

Station	Year	Group 1: Olli	Group 2: Dorsett	Group 3: Atlas	Group 4: Seirah	Group 5: Perth	Group 6: Beecher
Madison	1943	L	L	S	L	S	S
Sacaton	1943-44	L	L	L	S	S	L
Aberdeen	1944	M	S	M	M	M	S
Varieties represented number		96	2	9	1	3	8

TABLE 11.—*Width of leaves in 119 spring varieties*

[W, Wide; N, narrow]

Station	Year	Group 1: Manchuria	Group 2: Duplex	Group 3: Atsel	Group 4: Flynn 37
Madison	1943	W	W	W	W
Sacaton	1943-44	W	N	W	N
Aberdeen	1944	W	W	N	N
Varieties represented number		83	6	24	6

ANTHOCYANIN IN LEAF SHEATHS AND AURICLES

The development of anthocyanin color in leaf sheaths and auricles is influenced by climatic conditions to a high degree. It is possible to distinguish three groups on the basis of the quantity present,[1] namely, absent, present, or strong. The "absent" group is well defined, but the dividing line between the "present" and the "strong" groups is indefinite. The character can be used advantageously in classification when the anthocyanin is completely absent or is strongly expressed. In other cases it is of minor importance in describing varieties. Most varieties belong in the "present" group, as shown in tables 12, 13, and 14.

[1] Anthocyanin also is present in other plant parts discussed elsewhere.

TABLE 12.—*Anthocyanin color in basal leaf sheaths*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (119)

Station	Year	Group 1 (absent): Coast	Group 2 (present): California Mariout	Group 3 (strong): Hannchen
Madison	1943	A	P	S
Saenton	1943-44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented, number		5	93	21

WINTER VARIETIES (69)

Station	Year	Kirwin	Winter Club	Fayette
Madison	1942-43	A	P	A
Saenton	1943-44	A	A	S
Aberdeen	1944	A	P	S
Varieties represented, number		11	53	2

TABLE 13.—*Anthocyanin color in upper leaf sheaths*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (119)

Station	Year	Group 1 (absent): Coast	Group 2 (present): Flynn 37	Group 3 (strong): Hannchen
Saenton	1943-44	A	P	S
Aberdeen	1944	A	S or P	S
Varieties represented, number		33	74	12

WINTER VARIETIES (69)

Station	Year	Kirwin	Jackson	Marnobarb
Saenton	1943-44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented, number		32	32	5

TABLE 14.—*Anthocyanin color in auricles*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (119)

Station	Year	Group 1 (absent): Coast	Group 2 (present): Tregal	Group 3 (strong): Alpha
Madison	1943	A	P	P
Saenton	1943-44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented, number		5	82	32

WINTER VARIETIES (69)

Station	Year	Hooded 16	Kentucky 6	Fayette
Raleigh	1942-43	A	P	S
Madison	1943	A	P	S
Saenton	1943-44	A	P	S
Aberdeen	1944	A	S	S
Varieties represented, number		6	36	17

The observations as given in these tables were made at the following stages: The basal leaf sheaths in the tillering stage just before the lower leaves started to turn yellow; the upper leaf sheaths when the plants were ripe; and the auricles at the time of heading.

Waxiness of Leaf Sheaths and Leaves

The waxiness of leaf sheaths is one of the extremely variable characters in barley. No variety among those listed here is entirely free of waxiness, although such forms do exist. The present material can be classed in two groups, waxy and slightly waxy, but the two are not sharply delimited, as there is a continuous variation from one to the other, as shown in table 15. There is not enough difference in waxiness of leaves to make it possible to distinguish between groups, but such differences might occur in material of more divergent origin.

Table 15.—*Waxiness of leaf sheaths*

[W, Waxy; SW, slightly waxy]

SPRING VARIETIES (119)

Station	Year	Group 1: O. A. C. 21	Group 2: Chevron	Group 3: Warrior	Group 4: Flynn
Madison	1943	SW	SW	SW	W
Sacaton	1943–44	SW	SW	W	W
Aberdeen	1944	SW	W	W	W
Varieties represented, number		10	33	41	32

WINTER VARIETIES (69)

Station	Year	Tennessee Winter (C. I. 257)	Randolph	Texan	Davidson
Raleigh	1942–43	SW	SW	SW	W
Madison	1942–43	SW	W	W	W
Sacaton	1943–44	SW	SW	W	W
Aberdeen	1944	SW	SW	W	W
Varieties represented, number		13	10	9	7

Position of Leaves Before Heading

Notes on the position of leaves before heading, obtained on the spring varieties at Sacaton and Aberdeen, are given in table 16.

Table 16.—*Position of leaves before heading in 119 spring varieties*

[D, Drooping; U, upright]

Station	Year	Group 1: Odenbrucker	Group 2: Perth	Group 3: Hybrid Composite (Nebr. 38116?)
Sacaton	1943–44	D	U	U
Aberdeen	1944	D	D	U
Varieties represented, number		92	18	9

Whether the leaves are drooping or erect is easily determined just before heading. The character is not one of great importance, but it has some descriptive value; most of the varieties have drooping leaves.

Size and Shape of Flagleaves

Any observation on the size of leaves must be considered in the light of the variability caused by nutrition and climate. Yet it is sometimes possible to use the size and shape of the flagleaf. A detailed grouping is of little value, but the use of four groups, involving both size and shape—long, wide; long, narrow; short, wide; and short, narrow—is entirely feasible. It is evident from table 17 that most varieties belong in the group with long, wide leaves.

Curling of Flagleaves

The value of the curling of flagleaves was studied only in the spring varieties, as none were present in the winter varieties. Curled flagleaves seem to be present only on certain varieties that are related genetically. Environmental influences are likely to be noticeable on a leaf character of this type. For example, no curled leaves were noticed in 1943 at Madison and Fargo, but they were present at Sacaton and Aberdeen in 1944. This would seem to indicate that a dry climate is more favorable than a humid one for the development of this character. The data in table 18 show that varieties with typically curled flagleaves are rare and that a few are intermediate between curled and normal.

TABLE 17.—*Size and shape of flagleaves*

[LW, Long, wide; LN, long, narrow; SW, short, wide; SN, short, narrow]

SPRING VARIETIES (119)

Station	Year	Group 1 (long, wide) Velvon	Group 2 (long, narrow) Hannchen	Group 3 (short, wide) Hybrid Composite (Nebr. 38116)	Group 4 (short, narrow) Vaniee
Madison	1943	LW	LN	LW	LN
Sacaton	1943-44	LW	LN	SW	SN
Aberdeen	1944	LW	LN	SW	SN
Varieties represented, number		100	17	1	1

WINTER VARIETIES (69)

Station	Year	Tennessee Beardless 6	Awnless
Raleigh	1942-43	SW	SW
Beltsville	1942-43	LW	SW
Knoxville	1942-43	LW	SW
Madison	1942-43	LW	SW
Sacaton	1943-44	LW	SW
Aberdeen	1944	LW	SW
Varieties represented, number		65	4

TABLE 18.—*Curled and normal flagleaves in 119 spring varieties*

[C, Curled; SC, slightly curled; N, normal]

Station	Year	Group 1 (curled): Hero	Group 2 (slightly curled or normal): Lee	Group 3 (normal): Oderbrucker
Madison	1943	N	N	N
Fargo	1943	N	N	N
Sacaton	1943-44	C	SC	N
Aberdeen	1944	C	SC	N
Varieties represented ... number		2	26	91

STEM CHARACTERS

HEIGHT OF PLANT

The height of plant in this study was measured in inches from the ground to the base of the spike. The varieties at each station were placed in three groups by arbitrarily selecting class limits that would include about a third of the varieties in each. These groups were assigned the symbols S (short), M (midtall), and T (tall) (table 19).

TABLE 19.—*Height of plants*

[S, Short; M, midtall; T, tall, followed by figures showing actual height in inches]

SPRING VARIETIES (119)

Station	Year	Group 1 (short): California Mariout	Group 2 (short to midtall): Conway	Group 3 (midtall): Lee	Group 4 (midtall to tall): Plush	Group 5 (tall): Tall Comfort
Madison	1943	S 9	S 20	M 20	T 25	T 29
Do	1944	S 17	S 19	M 20	T 24	T 30
Fargo	1943	S 20	S 27	M 29	M 32	T 38
Do	1944	S 17	M 26	M 27	M 28	T 35
Lincoln	1943	S 17	M 27	M 25	M 27	T 31
Do	1944	S 11	S 10	S 19	M 24	M 29
Aberdeen	1944	S 23	S 28	M 30	T 38	T 38
Sacaton	1943-44	S 25	M 30	T 52	T 32	T 39
Brandon	1943	S 10	M 21	M 29	M 23	T 31
Do	1944	S 11	S 18	M 30	M 24	M 22
Ottawa	1943	S 26	M 37	S 16	T 41	T 47
Do	1944	S 38	M 49	S 18	T 50	T 57
Varieties represented ... number		25	27	23	28	16

WINTER VARIETIES (69)

Station	Year	Awnless	Poland	Reno	Kentucky 31	Iroki II
Raleigh	1942-43	S 21	S 21	M 23	T 29	T 32
Do	1943-44	S 27	S 31	M 31	T 37	T 45
Hartsville	1943-44	S 28	S 31	M 32	T 25	T 48
Knoxville	1942-43		M 29	T 32	M 29	T 43
Do	1943-44	S 43	M 40	S 37	M 40	T 46
Beltsville	1942-43	S 15	M 25	M 21	M 23	T 27
Do	1943-44	S 19	S 21	M 26	T 29	T 32
Urbana	1943-44		M 25	T 26	M 25	T 27
Columbia	1943-44	S 26	S 27	M 31	T 33	T 32
Hays	1942-43	S 21	M 25	M 26	T 27	T 36
Do	1943-44	S 32	S 31	M 34	T 29	T 25
Denton	1942-43		S 22	T 25	M 21	M 21
Sacaton	1943-44	T 48	S 39	M 43	M 45	T 49
Aberdeen	1944	S 37	M 40	S 39	T 43	T 49
Varieties represented ... number		1	23	20	21	6

Since the average height of all varieties varied a great deal from station to station and year to year, the actual height figure for the type variety of each group is included in the table also. The variation is from 9 to 39 inches for the symbol S, from 20 to 49 for M, and from 24 to 57 for T. It is also evident from the table that with such great variation it is impossible to establish clear-cut lines between short, midtall, and tall plants, as there is a continuous variation from the short plants to the tall ones; therefore, it is advantageous to use two additional groups, short to midtall and midtall to tall. Even then, the dividing lines between the groups are arbitrarily chosen, and the figures and symbols are sufficient proof of the limited use that can be made of plant height for taxonomic purposes.

Strength of Straw

There is no doubt that observations on strength of straw are very helpful in identifying certain varieties having either strong or weak straw, but observations on intermediate types are unreliable. The overlapping between the five arbitrary groups in table 20 is very noticeable, and it is very striking how seasonal conditions affect the straw strength. The observations from Fargo in 1943 show, for example, that most of the varieties had to be classified as having a weak or fairly weak straw. On the other hand, the observations from Lincoln in 1944 indicate that very little weight can be given to them, because weather conditions were not such as to induce lodging so as to bring out real differences. Strength-of-straw data are therefore useful only if they are based on tests carried out where significant differences occur.

Table 20.—*Strength of straw*

[G, Good; F, fair; W, weak]

SPRING VARIETIES (19)

Station	Year	Group 1 (stiff) Mars	Group 2 (moderately stiff to stiff) Flynn	Group 3 (moderately stiff) Prosper	Group 4 (moderately weak to weak) Rudlyn	Group 5 (weak) Manchuria
Madison	1943	G	F	F	W	F
Do	1944	G	G	F	F	W
Lincoln	1943	F	F	F	F	W
Do	1944	G	G	G	G	F
Fargo	1943	G	G	W	W	W
Do	1944	G	G	F	F	W
Aberdeen	1944	G	F	F	F	W
Brandon	1943	G	F	F	F	F
Do	1944	G	G	F	W	W
Ottawa	1944	G	F	F	F	W
Sutton	1943-44	G	G	F	W	W
Varieties represented number		15	21	52	23	7

WINTER VARIETIES (69)

Station	Year	Ecaw	Kentucky 6	Kentucky 11	Randolph	Purdue 1001
Urbana	1943-44	G	F	G	F	W
Hays	1943-44	G	G	F	W	W
Sutton	1943-44	G	G	F	F	W
Aberdeen	1944	G	F	F	W	P
Varieties represented number		16	11	5	11	1

Number of Exposed Nodes

The number of nodes exposed at the time the plants reach full height was considered as a possible taxonomic character; but, when studied on the winter barleys at three locations in 1943, the variation was so great that its use was abandoned. The data in table 21 illustrate this variability.

TABLE 21.—*Percentage of exposed nodes in 69 winter varieties*

Station	Year	Group 1: Jackson	Group 2: Scottish Pearl	Group 3: Reno	Group 4: Clemson Hooded	Group 5: Clemson Awnless
Knoxville	1942-43	0	0	0	0	0
Raleigh	1942-43	0	0	0	48	100
Beltsville	1942-43	5	50	90	90	80
Varieties represented number	.....	22	10	15	11	11

Anthocyanin in Nodes

The purple color in the nodes, caused by the presence of anthocyanin, occurs only when the nodes are exposed, that is, when the stem internodes have elongated far enough to bring the nodes out of the leaf sheaths. A variety may, however, show anthocyanin color in one locality and not in another. This again emphasizes the need of observations at several locations and in more than a single year if the character is to be used generally.

That most varieties belong in the intermediate group is evident from table 22. This is a broad group, from varieties with practically no anthocyanin to those rather heavily pigmented, but not enough to be classed as strong.

TABLE 22.—*Anthocyanin color in nodes*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (19)

Station	Year	Group 1 (absent Coast)	Group 2 (present Mars)	Group 3 (strong Rojo)
Madison	1943	A	P	S
Saanton	1943-44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented number		1	7	10

WINTER VARIETIES (69)

Station	Year	Wong	Smooth Awned 56	Fayette
Madison	1942-43		P	S
Saanton	1943-44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented number		1	58	11

Anthocyanin in Stems

The absence or presence of anthocyanin in the stems is a character of limited taxonomic use. In certain varieties the stem color is evident under nearly all conditions, but in most varieties it occurs only under very favorable dry, cool, sunny climates, as those at Saeaton and Aberdeen. The observations recorded in table 23 made at these two places refer to the part of the stem above the flagleaf and below the spike.

Table 23.—*Anthocyanin color in stems*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (110)

Station	Year	Group 1 (absent): Coast	Group 2 (present): Velvet	Group 3 (strong): Steigum
Saeaton	1943–44	A	P	S
Aberdeen	1944	A	P	S
Varieties represented.....number.		84	32	3

WINTER VARIETIES (60)

Station	Year	Kirwin	Randolph	Nassau
Saeaton	1943–44	A	P	P or S
Aberdeen	1944	A	P	S
Varieties represented.....number.		48	10	2

Shape of Neck

The normal stem is straight below the spike, but sometimes it is snaky (wavy), as illustrated in figure 5. Snaky neck is most often found in varieties with dense spikes and is frequently caused by environmental conditions. When the spike remains in the boot, or emerges only slightly, it is commonly found that the neck is snaky. This was observed in the material from Ottawa in 1943, when the barleys headed poorly. In some varieties the character is heritable, and the neck is snaky even if the spikes emerge normally, in which case it has some value in classification. The character is easily observed in some instances, but in others it is difficult to detect. Barley varieties showing this character are few as compared to those with normal necks, as is evident in table 24, where the observations on the spring varieties are given. No snaky-necked variety was found among the winter barleys.

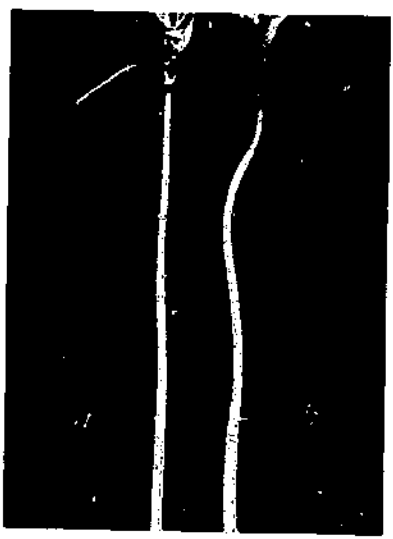

Figure 5.—Shape of neck: *a*, Straight; *b*, snaky.

TABLE 24.—*Shape of stem below spike in 110 spring varieties*

[N, Normal; S, snaky]

Station	Year	Group 1 (normal neck): Wisconsin Barbless	Group 2 (normal or snaky neck): Beecher	Group 3 (snaky neck): California Marfout
Madison	1943	N	N or S	N or S
Sacaton	1943-44	N	N	S
Aberdeen	1944	N	N or S	S
Varieties represented, number		110	8	1

DISTANCE FROM FLAGLEAF TO SPIKE

The distance from flagleaf to spike is determined both by heredity and environment (table 25). The good exsertion of spikes in the Manchuria-type barleys and their common failure to emerge in Compana are both heritable characters. The exsertion of 8 cm. of Oderbrucker at Madison in 1943 and of 18 cm. at Aberdeen in 1944 illustrates the influence of environment. Because of this influence it is impossible to arrive at any reliable average figure for distances. For the taxonomist the statement of the range will suffice. For Oderbrucker this is 8 to 18 cm.

TABLE 25. *Distance from flagleaf to spike*

SPRING VARIETIES (110)

Station	Year	Group 1 (long): Pontiac	Group 2 (medium long): Beecher	Group 3 (short): Trebi	Group 4 (very short): Compana
		Cm.	*Cm.*	*Cm.*	*Cm.*
Madison	1943	10	7	0	−7
Fargo	1943	12	4	2	0
Sacaton	1943-44	20	12	3	0
Aberdeen	1944	20	15	11	1
Varieties represented	number	33	57	25	1

WINTER VARIETIES (69)

Station	Year	Randolph	Wisconsin Winter	Tenkow	Texas Winter
		Cm.	*Cm.*	*Cm.*	*Cm.*
Raleigh	1942-43	10	4	0	−2
Beltsville	1942-43	11	11	6	5
Sacaton	1943-44	15	10	9	3
Aberdeen	1944	20	14	8	8
Varieties represented	number	29	41	1	2

In negative measurements, the spike did not emerge from the boot.

SHAPE OF COLLAR

The nodelike structure that marks the transition from the stem into the rachis of the spike is often called the collar. This name is used here as it describes the structure very well. Among cultivated barleys there are three types of collars closed, V-shaped, and open. They are shown in figure 6 in their typical form. A variation of the closed

or open type, which is unusual and easy to detect, is shown in the same figure. It is commonly found in Newal.

There are numerous variations between and within these typical forms as the groups in table 26 illustrate. It is difficult to find a

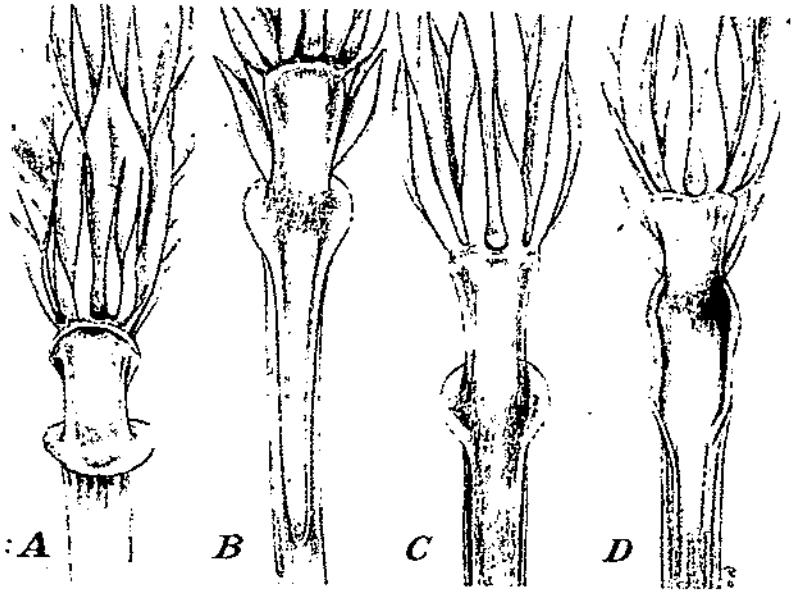

FIGURE 6.—Collar types; *A*, Closed; *B*, V-shaped; *C*, open; *D* modified closed or open, as in Newal.

TABLE 26.—*Shape of collar*

C, Closed; V, V-shaped; O, open

SPRING VARIETIES (119)

Station	Year	Group 1 (closed): Atlas	Group 2 (closed or V-shaped): Bay	Group 3 (V-shaped): Velvet	Group 4 (V-shaped, closed or open): Regal	Group 5 (closed or open): Short Comfort	Group 6 (open or V-shaped)	Group 7 (open)
Madison	1913	C	V	V	CO	OC	OV	0
Do	1911	C	V	V	COV	CO	OV	0
Fargo	1913	C	CV	VC	C	C	OV	0
Aberdeen	1913	C	CV	VC	CVO	CO	OV	0
Do	1910	C	V	V	C	C	OV	0
Sneaton	1913-11	C	CV	VC	CO	C	OV	0
Varieties represented, number		97	5	2	9	6	0	0

WINTER VARIETIES (39)

Station	Year	Davidson	Tucker	Awnless
Raleigh	1912-13	C	CVO	OC
Knoxville	1912-13	C	CVO	O
Beltsville	1912-13	C	CVO	CO
Denton	1912-13	C	CVO	O
Sneaton	1913-11	C	CV	OC
Aberdeen	1911	C	C	OC
Varieties represented, number		37	18	11

FIGURE 7.--Spikes of barley: *A*, Six-rowed; *B*, Two-rowed.

variety having all its collars of a single type, the nearest approach being in varieties having closed collars. Varieties with closed, occasionally V-shaped or open, collars are grouped with closed; and varieties with closed, sometimes V-shaped or open, collars with the group closed, V-shaped, or open. The gradual transition from closed collars to V-shaped and open ones, and the paucity of varieties with pure V-shaped or pure open type collars illustrates the complexity of the character. The observations recorded in table 26 also serve to emphasize the influence of environment, which must be considered whenever the character is used taxonomically.

SPIKE CHARACTERS

Number of Rows in Spike

The varieties in this study are grouped as either six-rowed (*Hordeum vulgare* L. emend. Lam.) or two-rowed (*Hordeum distichum* L. emend. Lam.) (figs. 7 and 8). These two characters are completely stable and very useful in taxonomic work. Table 27 gives the number of varieties falling in these two groups. As the winter varieties are six-rowed they do not appear in the table.

Although none of the varieties studied belong to the irregular barley group (*Hordeum irregulare* E. Åberg and Wiebe), this species ought to be mentioned (fig. 9). It was described by Åberg and Wiebe (3) and is

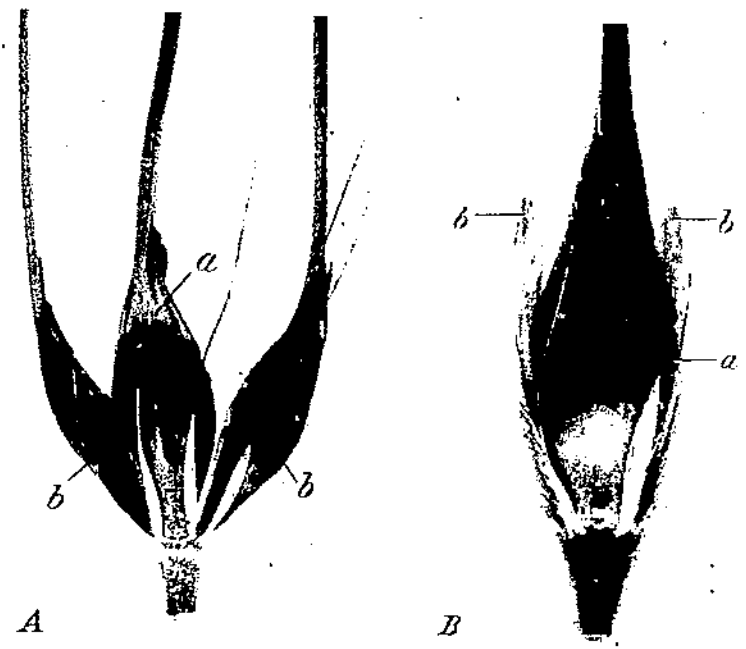

FIGURE 8.—Spikelets of barley. *A*, Six-rowed: *a*, Central kernel; *b*, lateral kernels. *B*, Two-rowed: *a*, Central kernel; *b*, lateral florets, sterile.

FIGURE 9.—Spike of *Hordeum irregulare*, irregular barley.

characterized by having the central florets fertile but the lateral florets reduced to rachillae in some cases and these distributed irregularly on the spike, with the remaining lateral florets either fertile, sterile, or sexless.

SHAPE OF SPIKE

Only two spike shape characters appear to have any taxonomic value. These are the parallel and the truncate pyramidal spikes illustrated in figure 10. The parallel type is most common; among 188 varieties only 7 are truncate pyramidal-shaped, but 5 others have a tendency in that direction. The 12 varieties are as follows:

Spikes truncate pyramidal:
- Club Mariout
- Searab
- Awnless
- Esaw
- Nakano Wase
- Sunrise
- Winter Club

Spikes tending to be truncate pyramidal:
- Minia
- Sanalta
- Clemson Awnless
- Marett Awnless 1
- Wong

The character truncate pyramidal seems to be stable, but is fully expressed only in well-developed spikes.

LENGTH OF SPIKE

Length of spike has only a limited value in the taxonomy of cultivated barleys and should be used mainly as a descriptive character. As can be seen in table 28, the character is influenced to such a high degree by nutritional and climatic factors that in most cases the influence of hereditary factors cannot be clearly separated. Extreme differences in length can be used satisfactorily to distinguish varieties; for example, Atsel has a very short spike, whereas Wisconsin Barbless has a very long one.

TABLE 27.—*Number of rows in spikes of 119 spring varieties*

[6, Six-rowed; 2, two-rowed]

Station	Year	Group 1 (six-rowed): Trebi	Group 2 (two-rowed): Spartan
		Number	*Number*
Madison	1943	6	2
Do	1944	6	2
Fargo	1943	6	2
Do	1944	6	2
Lincoln	1943	6	2
Do	1944	6	2
Aberdeen	1943	6	2
Do	1944	6	2
Sacaton	1943–44	6	2
Brandon	1943	6	2
Do	1944	6	2
Ottawa	1943	6	2
Do	1944	6	2
Varieties represented number		100	19

TABLE 28.—*Length of spikes*

SPRING VARIETIES (110)

Station	Year	Group 1 (very long): Wisconsin Barbless	Group 2 (long): Byng	Group 3 (midlong to long): Glabron	Group 4 (midlong): Prospect	Group 5 (midlong to short): Tunis	Group 6 (short): Atsel
		Cm.	*Cm.*	*Cm.*	*Cm.*	*Cm.*	*Cm.*
Madison	1943	9	8	7	6	4	2
Sacaton	1943–44	12	11	9	9	6	5
Aberdeen	1944	10	8	8	5.5	4	4
Varieties represented number		1	5	29	36	18	6

WINTER VARIETIES (69)

Station	Year			Olympia	Tennessee Winter (C.I. 257)	Nakano Wase	Awnless
				Cm.	*Cm.*	*Cm.*	*Cm.*
Raleigh	1942–43			9	7	5	4
Beltsville	1942–43			6	5	6	4
Knoxville	1942–43			8	7	4	5
Madison	1942–43			6	5		5
Sacaton	1943–44			9	8	7	5
Aberdeen	1944			9	6	5	5
Varieties represented number				15	48	4	2

WAXINESS OF SPIKE

Waxiness of spike refers to the waxy bloom on the epidermal tissues of the barley spike. Among the varieties included in this study, two have nonwaxy spikes, but all others have either slightly waxy or waxy spikes. As was the case with waxiness of leaf sheaths, these two latter groups cannot be sharply delimited and there is a large variation within the groups, as shown in table 29.

FIGURE 10.—Spike shapes: *A*, Parallel; *B*, truncate pyramidal.

SPIKE DENSITY

Linnaeus in 1753 (*15*) used spike density in his classification system, and it has been used repeatedly since that time. Körnicke used it in 1885 (*14*), and Atterberg in 1899 (*6*). Harlan (*12*) thought, in 1914, that as a character for use in isolation of types of breeding material or for identification of strains, its possibilities were far from exhausted. There is no doubt that barleys differ tremendously in spike density, yet this character presents certain difficulties in taxonomy. The differences between varieties are often small, and in spite of the fact that they are genetically distinct and stable under varying climatic conditions only a limited number of usable groups can be established, as shown in table 30. The groups are quite artificial, since the variation from lax to dense is an unbroken series (fig. 11).

From table 30 it is evident that density varies with environment. For example, spikes from Sacaton and Aberdeen are denser than those of the same varieties from the stations to the east. This difference is generally true for all varieties studied under the different climates that exist in the West, the Middle West, and the East. Harlan (*12*) found similar differences between varieties grown at Chico, Calif., and St. Paul, Minn. It also is interesting to note that a very high percentage of barleys grown in the United States and Canada is of the lax type. On a percentage basis 90 are lax, 4.5 are lax to dense, and 5.5 are dense.

Spike density is useful in classification if based on a limited number of groups and at the same time it is remembered that within these groups there are variations. The character is not very helpful, however, because of the large number of varieties that fall in the lax group.

TWEAKED SPIKE

Tweaked spike was found in only one variety, Wisconsin Barbless, among those studied, and only a small percentage of the spikes in this variety is so affected. In tweaked spikes one or more rachis internodes become elongated and rounded. Because of the elongation,

TABLE 29.—*Waxiness of spikes*

[NW, Nonwaxy; SW, slightly waxy; W, waxy]

SPRING VARIETIES (110)

Station	Year	Group 1: California Mariout	Group 2: Wisconsin Barbless	Group 3: Regal	Group 4: Atsel	Group 5: Flynn
Madison	1943	NW	SW	SW	SW	W
Swanton	1943–44	NW	SW	SW	W	W
Aberdeen	1944	NW	SW	W	W	W
Varieties represented ..... number		2	22	29	21	45

WINTER VARIETIES (69)

Station	Year		Kentucky 2	Tennessee Winter (C. I. 257)	Davidson	New Mexico Winter 1
Raleigh	1942–43		SW	SW	W	W
Madison	1942–43		SW	SW	W	W
Swanton	1943–44		SW	W	SW	W
Aberdeen	1944		SW	SW	W	W
Varieties represented ... number			18	41	9	1

TABLE 30.—*Spike density*

[Figures refer to the length in millimeters of one rachis internode]

SPRING VARIETIES (110)

Station	Year	Group 1 (very lax): Wisconsin Barbless	Group 2 (lax): White Smyrna	Group 3 (lax to dense): Conway	Group 4 (dense): Scarab
		Mm.	*Mm.*	*Mm.*	*Mm.*
Ottawa	1943	4.5	3.9	3.0	1.9
Fargo	1943	4.5	3.9	3.2	1.8
Madison	1943	4.1	3.8	3.2	2.4
Lincoln	1943	4.3	4.0	2.9	1.9
Aberdeen	1943	4.4	3.5	3.0	2.0
Do.	1944	3.9	3.2	2.9	2.0
Swanton	1943–44	3.8	3.3	2.4	1.7
Varieties represented ... number		2	106	7	4

WINTER VARIETIES (69)

Station	Year		Santiam		Wang
			Mm.		*Mm.*
Raleigh	1942–43		4.0		2.6
Knoxville	1942–43		3.7		2.3
Beltsville	1942–43		3.9		2.4
Denton	1942–43		4.0		2.6
Swanton	1943–44		3.4		1.8
Aberdeen	1944		3.8		2.0
Varieties represented ... number			63		6

the spike appears to have some spikelets missing. The appearance of the spike and of the rachis is shown in figure 12. Although the percentage of tweaked spikes may vary with the locality, they nevertheless are always present in fields of Wisconsin Barbless. The character is, therefore, of value in identifying this particular variety.

FIGURE 11.—Spike density: *A*, lax; *B*, dense.

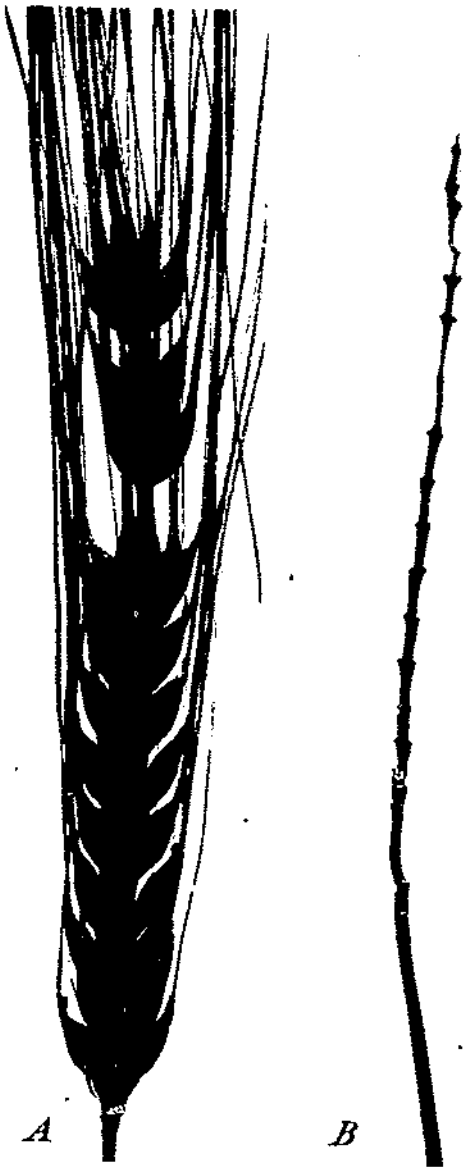

FIGURE 12.—Tweaking in Wisconsin Barbless: *A*, Spike; *B*, rachis.

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Number of Sterile Spikelets at Base of Spike

The number of sterile spikelets at the base of the spike is greatly influenced by environmental conditions, as shown in table 31. It is unlikely, however, that the groups of varieties represented by Scarab and Awnless will give the high number of sterile spikelets found in such varieties as Lico and Kentucky 11. These are, however, the extreme groups, and they represent only a small number of varieties as compared to the poorly delimited intermediate groups.

TABLE 31.—*Number of sterile spikelet groups at base of spike*

SPRING VARIETIES (119)

Station	Year	Group 1: Scarab	Group 2: California Coast	Group 3: Tall Comfort	Group 4: Lico
Madison	1943	0 to 1	1 to 2	1 to 2	2 to 3
Fargo	1943	1 to 2	1 to 2	3 to 4	3 to 4
Sacaton	1943–44	0 to 1	3 to 4	3 to 4	5 to 6
Aberdeen	1944	0 to 1	0 to 1	1 to 2	3 to 5
Varieties represented, number		15	45	49	10

WINTER VARIETIES (69)

Station	Year	Awnless	Wisconsin Winter	Kirwin	Kentucky 11
Raleigh	1942–43	0 to 1	1 to 2	2 to 3	3 to 4
Beltsville	1942–43	1 to 2	4 to 5	4 to 5	5
Knoxville	1942–43	1	4 to 5	1 to 5	5 to 6
Sacaton	1943–44	0 to 1	3 to 4	4 to 5	4 to 5
Aberdeen	1944	0	2 to 3	2 to 3	1 to 5
Varieties represented, number		8	7	52	2

Overlapping of Lateral Kernels

The overlapping of lateral kernels on lax spikes was responsible for the origin of the term "four-rowed barley," current in the early literature on barley classification. It is true that when most of the lateral kernels overlap the two lateral rows look as though they are one. In most cases, however, overlapping is found only in the upper part of the spike. The character has a very limited use for descriptive purposes, because of continuous variation from no overlapping to spikes in which the kernels in the upper two-thirds of the spike overlap. Table 32 shows the number of varieties having different degrees of overlapping and figure 13 illustrates two spikes, one of which has overlapping kernels and the other none.

Position of Spike

The position of the spike as it appears in the field at ripening time is a result of the nodding of the upper part of the stem combined with that of the spike itself. It can be expressed as the angle between the spike and the vertical. Characteristic spike positions are associated with certain groups of barleys. The erect to inclined type, that is, the type with a narrow angle, is common in the Coast group of barleys, and the nodding type, with a wide angle, is common among the Manchuria-O. A. C. 21-Oderbrucker group. Intermediate types and ex-

ceptions to the above are found in both groups. The observations on this character are summarized in table 33. It is evident that there is so much variation that the character can be used only in descriptions.

Toughness and Brittleness of Rachis

No variety included in this study has a brittle rachis. The distinction between the tough rachis, as found in this material, and the brittle rachis, as discussed by Åberg (*1*) for *Hordeum agriocrithon* and *Hordeum spontaneum*, is very easily detectable, as well as very stable. There are variations in degree of toughness, however, within the tough rachis group. This variation seems to be due both to genetic and to environmental factors. The first type, in which the rachis shows a tendency to be brittle, is found in Dorsett. Johnson and Åberg (*13*) found that Dorsett carries one of the complementary genes for brittle rachis, and it is possible that its tendency to brittleness is an expression of the gene in its single phase; or there may be additional genes for the same character, causing the same expression, although their effect is not strong enough to cause full brittleness.

The inducement of partial brittleness (or less toughness) by environments appeared in a few varieties grown under arid conditions. For example, hooded types had a partly brittle rachis when grown in the Western States and a definitely tough rachis when grown in the Southeastern States. This probably is caused by differences in the intake of ash, as the ash content of the awns of barley varieties grown at Aberdeen is 25 to 30 percent higher than for the same varieties grown at Raleigh, as found by Åberg, Wiebe, and Dickson (*4*). The tendency to a brittle rachis among normally tough rachis types is of very limited use in taxonomic work.

FIGURE 13. Overlapping of lateral kernels: *A*, Overlapping in upper part. *B*, no overlapping.

TABLE 32.—*Overlapping of lateral kernels*

SPRING VARIETIES (100)

Station	Year	Group 1 (none): Scarab	Group 2 (tendency at tip): Dorsett	Group 3 (at tip): Ottl	Group 4 (upper fourth): Prospect	Group 5 (upper third): Byng	Group 6 (upper half): Velvet	Group 7 (upper two-thirds): Wisconsin Barbless
Madison	1943	0	1/4	1/4	1/2	1/2	1/4	1/2
Saeaton	1943-44	0	0	0	1/2	1/2	1/2	1/2
Aberdeen	1944	0	1/4	1/4	1/2	1/2	1/2	1/2
Varieties represented, number		26	7	28	15	20	5	1

WINTER VARIETIES (69)

Station	Year	Winter Club	Iredell	Winter	Jackson	Poland
Raleigh	1942-43	0	0	1/2	1/2	1/2
Madison	1942-43	0	1/4	1/4	1/4	1/2
Saeaton	1943-44	0	1/2	1/2	1/4	1/2
Aberdeen	1944	1/2	1/2	1/2	1/4	1/2
Varieties represented, number		9	2	19	33	6

TABLE 33.—*Position of spikes (angle of spike from vertical)*

[Figures are in degrees]

SPRING VARIETIES (119)

Station	Year	Group 1 (nodding): O, A, C 21	Group 2 (inclined to nodding): Flynn I	Group 3 (erect to inclined): Velvon
Madison	1943	135	31	30
Aberdeen	1944	90	100	5
Varieties represented, number		61	21	37

WINTER VARIETIES (69)

Station	Year	Tennessee Winter C. I. 257	Bulgarian	Stanton
Raleigh	1942-43	180	90	0
Beltsville	1942-43	180	15	15
Aberdeen	1944	100	90	5
Varieties represented, number		51	7	8

HAIRINESS OF RACHIS EDGES

Most varieties have numerous hairs on the rachis edges, a few are intermediate, but only a very few have nonhairy edges. The first and last types are easily distinguished and stable, and therefore very useful

taxonomic characters. Table 31 shows the intermediate type further divided into three subgroups, characterized by no to few hairs, few hairs, and few to numerous hairs, thus covering a wide range. The variations among the varieties belonging to the three intermediate groups seem to be largely heritable rather than environmental, and thus can be separated from the two types with no hairs or with numerous hairs. Because of the overlapping ranges, only limited taxonomic use can be made of the three intermediate types. Types characterized by numerous hairs, few hairs, or absence of hairs are shown in figure 14.

FIGURE 14.—Hairiness of lateral edges: *A*, Hairy; *B*, Few hairs; *C*, No hairs.

TABLE 31. *Hairiness of intermediate types*

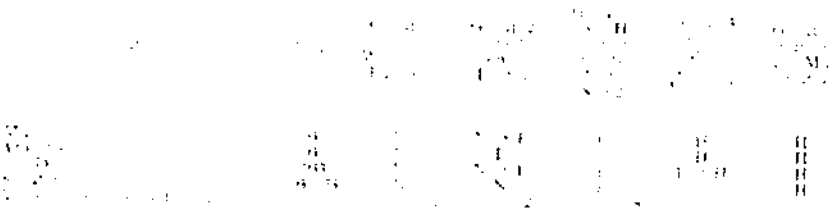


TABLE 34.—*Hairiness of rachis edges*—Continued

WINTER VARIETIES (69)

Station	Year	Group 1 (none): Smooth Awn 88	Group 2 (none to few): Jackson 1	Group 3 (few): Texan	Group 4 (few to numerous): Purdue 28156 A3-2-2-2	Group 5 (numerous): Davidson
Raleigh	1942-43	N	N	F	F or H	H
Knoxville	1942-43	N	N	F	F	H
Beltsville	1942-43	N	F	F	H	H
Denton	1942-43	N	N	H	F	H
Sacaton	1943-44	N	N	F	F	H
Aberdeen	1944	N	N	F	F or H	H
Varieties represented, number		1	4	3	1	60

LENGTH OF BASAL RACHIS INTERNODE

The length of the basal rachis internode often differs considerably from that of the other internodes of the rachis; it is shorter than the regular rachis internode in most cases, but longer in others. Wisconsin Barbless and Tall Comfort, for example, have long basal internodes in a large percentage of their spikes. In these varieties this character seems to be influenced very little by environmental conditions. But under special environments very long basal rachis internodes sometimes appear in varieties that otherwise are quite normal. P. W. Gull, from Stoneville, Miss., reported, for example, that Texan had extremely long basal rachis internodes. This seems to have been caused by a sudden rise in temperature about a month before heading. Similar observations have been made on other varieties in the greenhouse at Beltsville, Md.

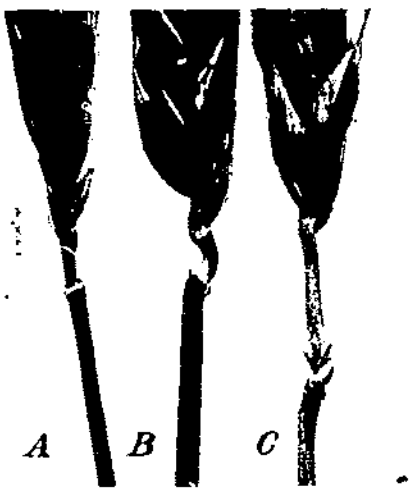


FIGURE 15.—Length and shape of basal rachis internode: *A*, Short, straight; *B*, short, curved; *C*, long, straight.

The differences between the lengths of basal rachis internodes falling in groups 2 to 4 in table 35 are of limited value taxonomically because differences are small. Very short or very long internodes are easy to detect and therefore quite useful. Differences in length of basal rachis internodes are shown in figure 15. The few cases in which the length of the basal internode is appreciably modified by environment help to maintain the value of the character.

SHAPE OF RACHIS INTERNODE

The basal rachis internode is straight or curved, as shown in figure 15. In table 36 it is seen that one or the other of these types occur in a number of varieties, but that both types are present in many

TABLE 35.—*Length of basal rachis internode*

SPRING VARIETIES (119)

Station	Year	Group 1 (<2 mm.): Sanalta	Group 2 (2 to 3 mm.): Pentland	Group 3 (3 to 4 mm.): Pontiac	Group 4 (4 to 5 mm.): Tregal	Group 5 (>5 mm.): Tall Comfort
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Madison	1943	2	3	4	6	3 to 7
Fargo	1943	1	3	3	5	6 to 12
Aberdeen	1943	2	2	3	3	6
Do	1944	1.5	2	4	4	6
Sacaton	1943–44	1.5	2	3.5	5 to 10	10
Varieties represented number		34	52	27	4	2

WINTER VARIETIES (60)

Station	Year	Esaw	Kentucky 1	Scottish Pearl	Polders
		Mm.	*Mm.*	*Mm.*	*Mm.*
Raleigh	1942–43	2	3	5	4
Knoxville	1942–43	1.5	2.5	3	4
Beltsville	1942–43	2	3	4	4
Denton	1942–43	2–1	2.5	2.5	3.5
Sacaton	1943–44	2	3	1	5
Aberdeen	1944	1.5	2.5	3	2.5
Varieties represented number		1	39	28	1

varieties. Climatic conditions have some influence on the expression of the character, nevertheless it is very useful for descriptive purposes. It is evident from tables 67 and 68 that curved internodes are more common among two-rowed than among six-rowed varieties. The Coast type appears to have a less curved internode than the Manchuria–O. A. C. 21-Oderbrucker type.

TABLE 36.—*Shape of basal rachis internode*

(C, Curved; S, straight)

SPRING VARIETIES (119)

Station	Year	Group 1 (curved): Glabron	Group 2 (curved or straight): Ezond	Group 3 (straight): Vaughn
Madison	1943	C	S	S
Aberdeen	1943	C	S	S
Fargo	1943	C	S	S
Sacaton	1943–44	C	C	S
Aberdeen	1944	C	C	S
Varieties represented number		27	47	45

WINTER VARIETIES (60)

Station	Year	Finley	Davidson	Huga
Raleigh	1942–43	C	S	S
Beltsville	1942–43	C	C	S
Knoxville	1942–43	C	S	S
Denton	1942–43	C	C	S
Sacaton	1943–44	C	S	S
Aberdeen	1944	C	S	S
Varieties represented number		2	41	26

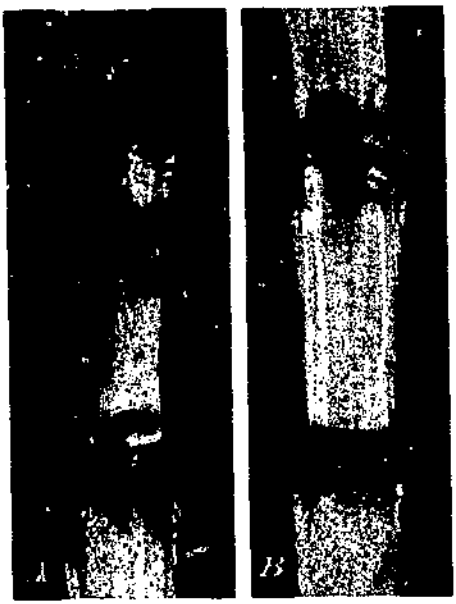


FIGURE 16.—Rachis internode shapes: *A*, Six-rowed type, sides tending to flare at upper end; *B*, two-rowed type, sides nearly parallel.

The shape of the other internodes of the rachis also differs between six-rowed and two-rowed barleys, as illustrated in figure 16. In six-rowed barleys the sides of the internode tend to flare so as to provide a wider area at the top for the attachment of lateral kernels. This difference in shape is a stable character.

GLUMES

In earlier literature a distinction was made between outer glumes, outer flowering glumes, and inner flowering glumes. A simplification resulted in the adoption of the terms "outer glumes," "lemma," and "palea." It now seems desirable to carry the simplification a step further with respect to the first of these terms and to use it simply as "glumes." The terms will, therefore, be glumes, lemma, and palea.

GLUME LENGTH

The actual length of the glume is of little value to the taxonomist, but the length of the glume expressed in relation to the length of lemma has a definite value. For most varieties this length is about half, but occasionally it is one-third or two-thirds of that of the lemma. A difference in length usually can be observed easily. Table 37 gives the observations on this character, and it is evident that the character is stable. Since practically all varieties fall in one group, however, the usefulness of the character is greatly restricted.

TABLE 37.—*Length of glumes in relation to length of kernel*

SPRING VARIETIES (1919)

Station	Year	Group 1 ($\frac{1}{3}$)	Group 2 ($\frac{1}{3}$ to $\frac{1}{2}$): Hybrid Composite (Nebr. 381162)	Group 3 ($\frac{1}{2}$): Manchuria (C. I. 2330)	Group 4 ($\frac{1}{2}$ to $\frac{2}{3}$): Hybrid Composite (Nebr. 381175)	Group 5 ($\frac{2}{3}$): Californium Marlout
Madison	1913		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{2}{3}$
Fargo	1913		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{3}$	$\frac{2}{3}$
Saginaw	1913–14		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$ to $\frac{2}{3}$	$\frac{2}{3}$
Aberdeen	1914		$\frac{1}{2}$ to $\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{2}{3}$
Varieties represented...number			1	106	1	1

TABLE 37.—*Length of glumes in relation to length of kernel*—Continued

WINTER VARIETIES (69)

Station	Year	Group 1 (1a): Sunrise	Group 2 (1a to 3a): Esaw	Group 3 (3d): Tennessee Winter (C. I. 257)	Group 4 (1a to 3a): Bulgarian	Group 5 (3a)
Raleigh	1942–43	1/4	1/2	1/2	1/4	
Beltsville	1942–43	1/4	1/2–3/4	1/2	1/4–1/2	
Knoxville	1942–43	1/4	1/2–3/4	1/2	1/4–1/2	
Madison	1942–43	1/4		1/2	1/4–1/2	
Scranton	1943–44	1/4	1/2	1/2	1/4–1/2	
Aberdeen	1944	1/4	1/2–3/4	1/2	1/4–1/2	
Varieties represented, number		2	1	65	1	

HAIRINESS OF GLUMES

The hairs on the glumes are short or long; and either cover the entire glume, are confined to a band running lengthwise on the glume, or are restricted to the midline. In a few varieties no hairs are present. The four types are shown in figure 17. The character is

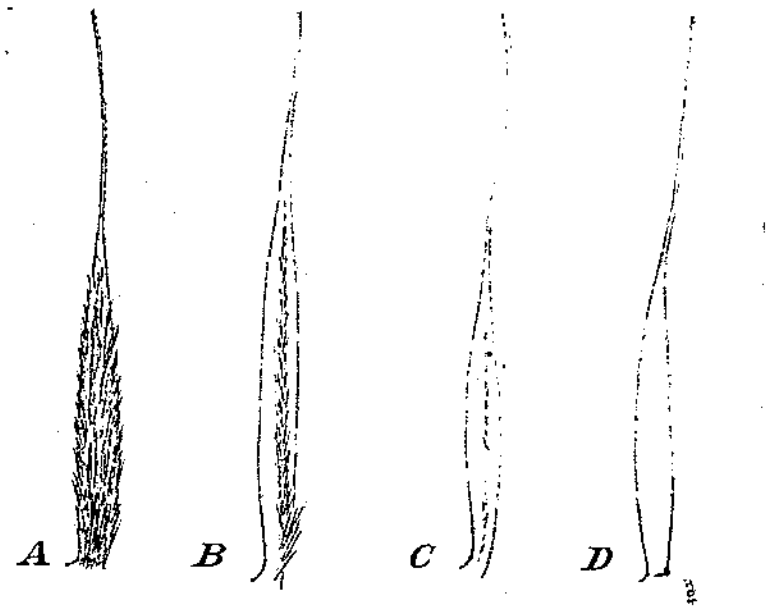


FIGURE 17.—Hairiness of glumes: *A*, Covered; *B*, in band; *C*, on midline; *D*, without hairs.

stable in many varieties, but varies greatly in others. In Manchuria (C. I. 2947) the glumes are completely covered with short hairs and the character is stable, but in Kentucky 11 practically all types of hairiness are found. Between these two extremes are numerous intermediate types, the distribution and frequency of which are shown in table 38. In classification the value of a character depends entirely on how it is applied. The distinction between the stable and

TABLE 38.—*Length and distribution of hairs on glumes*

[S, Short hairs; L, long hairs; C, hairs covering the glumes; B, hairs confined to bands on glumes; M, hairs restricted to midline of glumes; N, no hairs on glumes

SPRING VARIETIES (119)

Station	Year	Group 1: Manchuria (C. I. 2947)	Group 2: Lico	Group 3: Ezond	Group 4: Velvon 11	Group 5: Pontiac	Group 6	Group 7	Group 8: Hannchen (C. I. 531)	Group 9: California Marlout	Group 10: Plush	Group 11: Rojo	Group 12: Glabron	Group 13: Wisconsin Barbless
Madison	1943	SC	SB	SB	SB	SLC	.....	.....	LC	LC	LB	LB	N or LM	N
Aberdeen	1943	SC	SC or SB	SB or SM	SM or N	SLC	.....	.....	LC	LB	LB	LM	N or LM	[1] N or LM
Do	1944	SC	SC	SB	SB	LC	.....	.....	LC	LC	LB	LM	N or LM	[1] N or LM
Sacaton	1943-44	SC	SC	SB	SM	SLC	.....	.....	LC	LB or LC	LB	LB	LM	N
Varieties represented, number	.....	49	4	1	3	3	.....	.....	10	22	7	8	11	1

WINTER VARIETIES (69)

Station	Year	Tennessee Winter (C. I. 257)		Jackson 1	Nassau	Reno	Kentucky 11	Smooth Awn 86	Wong	Marett Awnless 1		Smooth Awn 88		
Raleigh	1942-43	SC	.....	SB	SB	SLC	SLCBM or N	SLM	LC	LB	.....	LM	.....	.....
Knoxville	1942-43	SC	.....	SB	SB	SLC	LCB	SB	LC	LC	.....	LB	.....	.....
Beltsville	1942-43	SC	.....	SB	SM	SLC	SLB	SLM	LC	LC	.....	LM or LB	.....	.....
Denton	1942-43	SC	.....	SC or SB	SB	SLC	SLC	SB	LC	LC	.....	LB	.....	.....
Sacaton	1943-44	SC	.....	SB	SM	SC	LB	SM	LC	LB	.....	LM	.....	.....
Aberdeen	1944	SC	.....	SB	SM	SC	SM	N or SM	LC	LC	.....	LB	.....	.....
Varieties represented, number	.....	45	.....	2	1	4	2	4	3	7	.....	1	.....	.....

[1] Occurs only occasionally.

variable cases is very useful. If several observations under different conditions are available for the variable groups they can be used for descriptive purposes. Sometimes they can even be applied in varietal keys.

It is interesting to note that most of the varieties showing variability for this character are of hybrid origin and many of them have Lion in their parentage, whereas the character is stable in most of the old introductions and reselections from them.

Length of Glume Awns

Insofar as is known, no previous writers have used the length of the glume awn in barley classification. It can, however, be used with very good success if based on the relationship between the length of the glume awn and the glume itself. To be reliable, the observation must be taken after the spikes are fully developed but before they are ripe. When ripe, the fine glume awn is dry and easily broken. In most barleys the glume awn is either equal to the glume in length or twice as long, as shown in figure 18. This character is very stable under varying environmental conditions, as is shown in table 39.

Of the spring barleys included in table 39, 50 percent have glume awns equal in length to the glume and 40 percent twice that length. Among the winter barleys the corresponding figures are 12 and 84 percent, respectively, but among the winter barleys there also is one variety with short glume awns that are only ½ to 1 times the glume length and another that has glume awns which are only ¼ to ½ times the length of the glume. The various groups established showed little

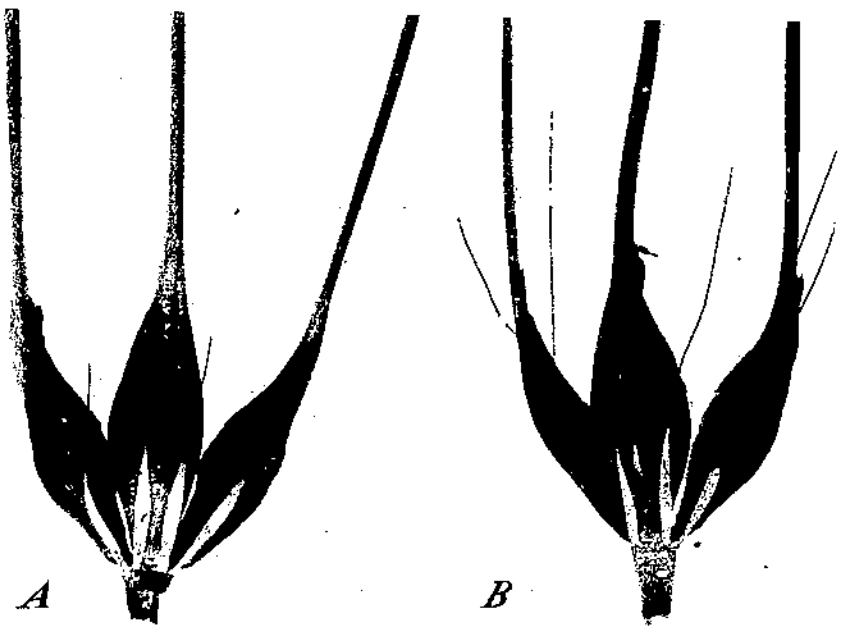


FIGURE 18.—Length of glume awns: *A*, Glume awn equal to length of glume; *B*, glume awn twice the length of glume.

TABLE 39.—*Length of glume awn in relation to length of glume*

SPRING VARIETIES (110)

Station	Year	Group 1 (2× length of glumes): Tall Comfort	Group 2 (1½× length of glumes): Nobarb	Group 3 (2× or 1× length of glumes): Prospect	Group 4 (1× length of glumes): Wisconsin Barbless	Group 5 (½ to 1× length of glumes)	Group 6 (¼ to ½ length of glumes)
Madison	1943	2	1 to 1½	2	1	...	...
Do	1944	2	2	1 or 2	1	...	...
Fargo	1943	2	2	2	1	...	...
Do	1944	2	1 to 2	1 or 2	1	...	...
Lincoln	1944	2	2	1 or 2	1	...	...
Aberdeen	1944	2	1 to 1½	1	1	...	...
Sacaton	1943–44	2	1 to 2	1	1	...	...
Varieties represented, number		47	7	5	60	...	...

WINTER VARIETIES (69)

Station	Year	Tennessee Winter (C. I. 257)	Nassau	Davidson	Esaw	Awnless
Raleigh	1942–43	2	1 or 2	1	½	¼
Knoxville	1942–43	2	1	1	½	½
Beltsville	1942–43	2	1 or 2	1	½	¼ to ½
Hays	1943–44	2	1 or 2	1	¼	¼
Denton	1943–44	2	1 or 2	1	¾ to 1	½
Sacaton	1943–44	2	2	1	½ to 1	¼
Aberdeen	1944	2	2	1	½	¼
Varieties represented, number		58	8	8	1	1

or no variation under the various climatic conditions where they were studied, and for this reason this character is very useful in classification. Altogether the stable groups represent 90 percent of the spring barleys and 99 percent of the winter barleys. The two small groups represented by Nassau among the winter varieties and by Prospect in the spring varieties have two types of glume awn length; they are stable, but the varieties are mixed for this character. As they are of hybrid origin, the glume awn character probably was heterozygous when the selection was made. The group, exemplified by Nobarb and representing 7 percent of the spring varieties, is intermediate in glume awn length, and many of the varieties come from an Atlas × Vaughn cross. The glume awns in this group may be 1, 1½, or 2 times the length of the glumes and therefore only of limited value in taxonomic work.

BARBING OF GLUME AWNS

The occurrence of smooth and semismooth glume awns is very rare, since only one variety, Ezond, has smooth glume awns and another one, Texan, semismooth awns, among the 188 varieties studied. A variation in roughness was noted among the varieties with rough glume awns. Wisconsin Barbless and Glabron, spring varieties, and Jackson and Jackson 1, winter varieties, appear to have less roughness than other varieties in these groups.

Length of Awns

The length of awns is not a simple character genetically. It is therefore difficult to use narrow limits for this character in taxonomy because of the frequent overlapping that occurs. A division into short and long awns is easily made, as is likewise a grouping based on the relative length of the awns on central and lateral lemmas. But within these groups there are numerous minor variations that are not easily separated. Thus long awns in the long group are not of equal length. The relation between the awn length and spike length also is not always the same. In a general classification where environmental conditions may cause important changes, such minor differences should not be used. They do have value, however, under a particular environment. The awn lengths, given in tables 40 and 41, are actual lengths in centimeters measured from the base to the tip. The awn length in relation to the spike length is expressed as a ratio of the distance the awns extend beyond the tip of the spike and the length of the spike itself. Awned, awnleted, and awnless spikes are shown in figures 19 and 20, together with hooded spikes, the other type of lemma appendage occurring in barley.

TABLE 40.—*Length of awns*

SPRING VARIETIES (10)

Station	Year	Group 1 (long): Vaughn	Group 2 (long): Glabron	Group 3 (long on central row, shorter on lateral rows): Hybrid Composite (Nebr. 381162)	Group 4 (short)	Group 5 (short on central row, still shorter or missing on lateral rows)	Group 6 (short on central row, still shorter or missing on lateral rows)
		Cm.	*Cm.*	*Cm.*			
Madison	1943	11	11	11			
Sneaton	1943-44	12	9	7			
Aberdeen	1944	13	10	10			
Varieties represented . . number	-	22	17	1			

WINTER VARIETIES (63)

Station	Year	Wintex	Marmo-lorh	Esaw	Wong [2]	Sunrise [3]
		Cm.	*Cm.*	*Cm.*	*Cm.*	*Cm.*
Raleigh	1942-43	16	11	1.5	7	2 [1]
Bedsville	1942-43	15	12	1	5	7
Knoxville	1942-43	11	11	1	1	
Sneaton	1942-43	10	10	2	1	2
Aberdeen	1944	13	12	5	0 to 5	0 to 2
Varieties represented . . number		10	8	5	5	0 to 2
				1	3	2

[1] Data refer to central awns; lateral awns are about 2 cm. shorter.
[2] Data refer to central awns; lateral awns are about 3 cm. shorter.
[3] Data refer to central awns; lateral awns are missing.

FIGURE 19.—Awn types: *A*, Long; *B*, short; *C*, short on central rows, awnleted on lateral rows; *D*, awnleted on central rows, awnless on lateral rows.

FIGURE 20.—Awnless and hooded types; *A*, Awnless; *B*, elevated hoods; *C*, sessile hoods.

TABLE 41.—*Length of awn in relation to length of spike*

[Figures are ratio of awn length to spike length]

SPRING VARIETIES (110)

Station	Year	Group 1 (long): Vaughn	Group 2 (long): Glabron	Group 3 (long on central row, shorter on lateral rows): Hybrid Composite (Nebr. 381162) [1]	Group 4 (short)	Group 5 (short on central row, still shorter or missing on lateral rows)	Group 6 (short on central row, still shorter or missing on lateral rows)
Madison	1943	3.0	1.3	2.0	....	....	....
Sacaton	1943-44	1.5	.9	.6	....	....	....
Aberdeen	1944	2.5	.9	1.5	....	....	....
Varieties represented, number		75	34	1	....	....	....

WINTER VARIETIES (53)

Station	Year	Wintex	Marmo-barb		Esaw	Wong [2]	Sunrise [3]
Raleigh	1942-43	1.5	1.2	....	0.5	0.8	0
Beltsville	1942-43	1.6	1.3	....	.6	.8	0
Knoxville	1942-43	1.5	1.0	....	.5	.2	0
Sacaton	1942-43	1.2	.8	....	.3	0 to 5	0
Aberdeen	1944	2.0	1.2	....	.5	.5	0
Varieties represented, number		39	10	....	1	1	2

[1] Data refer to central awns; lateral awns are about 2 cm. shorter.
[2] Data refer to central awns; lateral awns are about 3 cm. shorter.
[3] Data refer to central awns; lateral awns are missing.

BARBING OF AWNS

The three awn groups—smooth, semismooth, and rough—in barley are in part artificial (fig. 21). Entirely smooth awns are not found among the varieties studied, as the so-called smooth-awned types have varying numbers of fine barbs at the tip. The length of this rough segment, from the tip downwards, is the determining factor as to whether an awn is smooth or semismooth. When the barbed segment does not include more than the upper third of the awn a variety is classed as smooth. When it extends farther down on the awn but still leaves the basal part smooth, it is classed as semismooth. Rough awns have barbs from the tip to the base. The three types of awns are shown in figure 21. The degree of smoothness of the awn depends not only upon genetic factors but also on environment. For example, at Madison, in 1943, many of the normally smooth-awned barleys were classified as semismooth. Similar observations were made on smooth-awned varieties when grown at Sacaton and Aberdeen. This would indicate that, although in general a grouping into smooth and semismooth awns can be made, it must be recognized that environment may cause some overlapping between the groups. Fortunately, however, only a few types fall on the border line between smooth and semismooth awns. It usually is easy to separate semismooth and rough types, although occasionally semismooth awns are almost fully barbed.

Table 42 shows the groups made with this material. Groups 2, 3, and 4 represent the semismooth varieties; and of these, group 2 includes those bordering between smooth and semismooth, and group 4 those between semismooth and rough.

Deciduous Awns

The deciduousness of awns in barley is highly dependent on environmental conditions but also is heritable. Deciduous awns are found most commonly among barleys grown in dry climates and on soils high in available minerals, where the plants accumulate a high percentage of ash, especially in their awns. It is likely that the percentage of ash has some influence on the deciduousness of awns. There is also a genetic influence, however, because some varieties lose *all* their awns under certain environments, whereas others lose none. There is an association also between deciduousness and the types of barley. The Coast-type barleys seldom lose any awns, while some two-rowed types and the Manchuria-O. A. C. 21-Oderbrucker types lose theirs frequently. The figures in table 43 indicate that the number of varieties with a high percentage of deciduous awns is comparatively small.

Anthocyanin in Glume Awns and Awns

There is a close association of anthocyanin color in the glume awns and the awns, and the character is therefore treated under a single heading. Although the anthocyanin color has a certain descriptive value, it is highly variable and needs to be studied at several locations before the characteristics of a variety can be ascertained. Tables 44 and 45 show this variation. Only occasional varieties completely lack purple anthocyanin color. A moderate number of varieties are strongly colored, while the majority of the varieties are intermediate. This scarcity of varieties in the easily recognized groups makes the character of limited value.

Figure 21. Barbs on awns: *A*, Rough; *B*, semismooth; *C*, smooth.

TABLE 42.—*Smoothness and roughness of awns*

[S, Smooth; SS, semismooth; R, rough]

SPRING VARIETIES (110)

Station	Year	Group 1 (smooth): Mars	Group 2 (smooth): Rojo	Group 3 (semi-smooth): Conway	Group 4 (semi-smooth): Beecher	Group 5 (rough): Oderbrucker
Madison	1943	S	SS	SS	R	R
Do	1944	S	S	S	SS	R
Fargo	1943	SS	S	SS	SS	R
Do	1944	S	S	S	SS	R
Lincoln	1944	S	S	S	SS	R
Aberdeen	1944	S	S	SS	SS	R
Sacaton	1943–44	S	SS	SS	R	R
Varieties represented . number		30	11	7	11	51

WINTER VARIETIES (53)

Station	Year	Texas	Nassau			Davidson
Raleigh	1942–43	S	S			R
Hays	1942–43	S	SS			R
Sacaton	1943–44	S	S			R
Aberdeen	1944	S	S			R
Varieties represented . number		9	1			43

TABLE 43.—*Percentage of deciduous awns in 110 spring varieties*

Station	Year	Group 1 (0 to 25 percent): Ezond	Group 2 (25 to 50 percent): Glabron	Group 3 (50 to 75 percent): Hannchen	Group 4 (75 to 100 percent) Stephan
		Percent	*Percent*	*Percent*	*Percent*
Fargo	1943	10	60	70	70
Sacaton	1943–44	0	40	75	100
Aberdeen	1944	0	20	20	90
Varieties represented . number		86	17	2	5

TABLE 44.—*Anthocyanin color in glume awns*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (110)

Station	Year	Group 1 (absent): Coast	Group 2 (present): Vaughn	Group 3 (present): Ezond	Group 4 (strong): Rojo
Madison	1943	A	A	P	S
Sacaton	1943–44	A	P	P	S
Aberdeen	1944	A	P	S	S
Varieties represented . number		6	10	61	12

WINTER VARIETIES (60)

Station	Year	Kirwin	Poland	Jackson	Marquis
Raleigh	1942–43	A	P	P	A
Beltsville	1942–43	A	P	P	S
Knoxville	1942–43	A	A	S	S
Sacaton	1943–44	A	P	S	S
Aberdeen	1944	A	P	S	S
Varieties represented . number		7	11	17	1

TABLE 45.—*Anthocyanin color in awns*

[A, Absent; P, present; S, strong]

SPRING VARIETIES (116)

Station	Year	Group 1 (absent): Centt	Group 2 (present): Vaughn	Group 3 (present): Ezond	Group 4 (strong): Rojo
Madison	1943	A	A	P	S
Saeaton	1943-44	A	P	P	S
Aberdeen	1944	A	P	S	S
Varieties represented..... number		2	40	38	9

WINTER VARIETIES (53)

Station	Year	Kirwin	Poland	Jackson	Marmonbarb
Raleigh	1942-43	A	A	P	S
Beltsville	1942-43	A	P	P	S
Knoxville	1942-43	A	P	P	S
Saeaton	1943-44	A	P	S	S
Aberdeen	1944	A	P	P	P
Varieties represented number		8	33	11	1

HOOD CONTRASTED WITH AWNS

It is very easy to distinguish between hoods and awns on the lemma, as shown in figures 19 and 20. The character is very stable under all climatic conditions and very useful in classifying varieties. There are 9 hooded varieties among the 119 spring varieties and 13 hooded varieties among the 69 winter varieties reported here.

ELEVATION OF HOODS

Elevation of hoods sometimes is useful in classification. The difference between elevated or sessile hoods is sometimes very distinct, as seen in figure 20. Table 46 shows, however, that there also are varieties in which, for example Clemson Hooded, it is difficult to decide whether the hoods are elevated or not. The character also varies from one locality to another and to be useful in classification must be based on observations under several environments.

TABLE 46.—*Elevation of hoods*

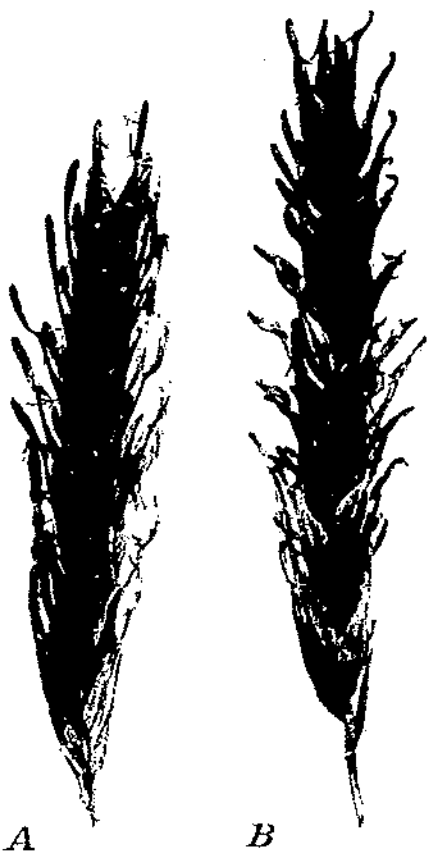
SPRING VARIETIES (9)

Station	Year	Group 1 (sessile 0): Warrior	Group 2 (sessile or elevated): Union Beardless	Group 3 (elevated): Horsford
		Mm.	*Mm.*	*Mm.*
Fargo	1943	0	4	6
Madison	1943	0	0	4
Saeaton	1943-44	2 to 3	2 to 3	5 to 10
Aberdeen	1944	0	0	4
Varieties represented number		1	5	3

TABLE 46.—*Elevation of hoods*—Continued

WINTER VARIETIES (3)

Station	Year	Group 1 (sessile 1)	Group 2 (sessile or elevated): Clemson Hooded	Group 3 (elevated): Tennessee Beardless 5
			Mm.	*Mm*
Raleigh	1942-43		2	3
Knoxville	1942-43		3	4
Beltsville	1942-43		1	4
Madison	1942-43		0	5
Saanton	1943-44		1	7 to 10
Aberdeen	1944		0 to 2	2 to 4
Varieties represented	number		7	6



A *B*

FIGURE 22.—Hood appendages on middle lobe: *A*, With appendage; *B*, without appendage.

HOOD APPENDAGES ON MIDDLE LOBE

The hooded barleys often have a delicate awnlike appendage attached to the middle lobe of the hood. Observations on the existence of such an appendage were made in the field and on spikes received from the different localities where the classification nurseries were grown. As between stations the character was comparatively stable and, therefore, has a certain taxonomic value. The only difficulty in applying it lies in the ease with which the appendages break off from the hoods in the ripe spikes. A grouping of the hooded varieties in this study as to occurrence of hood appendages is given below. The largest percentage occurs in the winter varieties. The spikes in figure 22 illustrate the presence and absence of the hood appendage.

Spring varieties:

Without appendage — Meloy, Belford

With very short appendage or without. — Horsford, Meloy 3, Sixty Day, Colsess, Union Beardless, Warrior, Composite Cross selection (C. I. 5449)

Winter varieties:	
Without appendage	Huga
With short appendage	Hooded 16, Tennessee 4B17–640, Brugh 76, Clemson Hooded, Tucker, Missouri Early Beardless, Tennessee Beardless 5, Tennessee Beardless 6, York Hooded, Marett Hooded 4, Iredell, North Carolina Hooded 26

Length of Stamens

The limited number of observations made on the length of stamens indicate that it occasionally can be of taxonomic value. The stamens of Nakano Wase, for example, are shorter (averaging 2.5 millimeters) than those of other winter varieties, having 3-millimeter stamens. This difference, however, is so small that it is difficult to use the character. Stamen length also varies with locality. At Aberdeen, the stamens were 1 mm. longer on an average than at the other stations where the nurseries were grown. It is concluded that stamen length is a useful character in taxonomic work only in exceptional cases.

Hairiness of Stigma

The hairiness of stigma (fig. 23) is not an important character for two reasons: First, the period when it can be observed is very short; second, the hairiness is closely associated with the barbs on the awns, that is, a variety that has only a few hairs on its stigma nearly always has smooth awns and a variety with numerous hairs

FIGURE 23. Stigma hairiness: *A*, Hairy; *B*, with few hairs.

on its stigma has rough awns. The observations on the hairiness of stigma are therefore only an additional measure of the smoothness or roughness of the awns. In a few cases the hairiness of stigma is intermediate between the two types just mentioned and may not be associated with semismooth awns. Observations on hairiness of stigma, given in table 47, demonstrate that the two groups, hairy and with few hairs, are distinct. Within each one of these groups are variations as to hairiness, particularly in the group with few hairs.

TABLE 47.—*Hairiness of stigma*

[H, Hairy; M, moderately hairy; F, few hairs]

SPRING VARIETIES (119)

Station	Year	Group 1 (hairy): Oderbrucker	Group 2 (moderately hairy): Compana	Group 3 (few hairs): Mars
Madison	1943	H	M	F
Sacaton	1943–44	H	F	F
Aberdeen	1944	H	M	F
Varieties represented ..... number		68	12	39

WINTER VARIETIES (69)

Station	Year	Penn. Winter (C. I. 257)		Marmotarh
Madison	1942–43	H		F
Sacaton	1943–44	H		M
Aberdeen	1944	H		F
Varieties represented ..... number		60		

THRESHABILITY AND SHATTERING

Two objectives are sought in threshing, namely, to remove the kernel from the rachis and to break the awn from the kernel. The ease with which this is accomplished depends on the type of barley. The Coast type threshes very poorly, whereas the Manchuria-O. A. C. 21–Oderbrucker type threshes quite easily. The locality where the barley is grown also seems to have an influence, for if it is grown where the ash content of the plant is high then it will thresh easily, whereas a low ash content causes poor threshing. An example of the relationship of ash content and threshability is furnished by winter barleys grown at Raleigh and Aberdeen. The ash analyses from such barleys were reported by Åberg, Wiebe, and Dickson (*4*), who found that a difference of 25 percent in total ash content in the awns had a marked influence on the ease with which the awns broke off.

The varieties from the barley-classification nurseries at Madison in 1943, at Raleigh in 1942–43, and at Aberdeen in 1944 were tested for threshability by the use of a Vogel thresher, using a cylinder speed of 745 revolutions per minute. The construction of this thresher was discussed by Vogel and Johnson in 1934 (*18*). The varieties from Madison and Raleigh were graded after one threshing, then run through the machine a second time and graded again. At Aberdeen only one threshing was made. The results from these tests are summarized in table 48.

The basis for differences in threshability is the same or very similar to the one for shattering. It is well known that the middle western varieties shatter when grown in the dry climate in the West. The observations on shattering at Sacaton and Aberdeen are presented in table 49.

TABLE 48.—*Threshability in spring and winter varieties*

[G, Good; M, medium good; P, poor]

SPRING VARIETIES (119)

Station	Year	Group 1: Oderbrucker	Group 2: Trebi	Group 3: Blue
Madison:				
First threshing	1943	G	M	P
Second threshing	1943	G	G to M	M
Aberdeen	1944	G	G	M to P
Varieties represented.....number		60	10	10

WINTER VARIETIES (60)

Station	Year	Wong	Randolph	Kentucky 1
Raleigh:				
First threshing	1942–43	G	M to P	P
Second threshing	1942–43	G	G to M	M
Aberdeen	1944	G	G	M
Varieties represented.....number		13	40	16

TABLE 49.—*Shattering in 119 spring varieties*

[S, Shattering; N, nonshattering]

Station	Year	Group 1 (shattering): Oderbrucker	Group 2 (intermediate shattering): Tregal	Group 3 (nonshattering): Blue
Sacaton	1943–44	S	S	N
Aberdeen	1944	S	N	N
Varieties represented.....number		16	21	22

KERNEL CHARACTERS

NAKED CONTRASTED WITH COVERED KERNELS

The distinction between naked kernels, where the lemma and palea are not attached, and covered kernels, where they are attached, is one of the easiest characters in barley to recognize. The character is stable and consequently very useful. Naked and covered kernels are shown in figure 24.

KERNEL LENGTH

Kernel length can be measured either on the spikes or after threshing. Before observations on the influence of environment on the character could be made, it was necessary to find a technique whereby the determination could be made rapidly and reliably. Studies for this purpose were carried out during the winter of 1942–43 at Madison. The material chosen was such that observations could be made on the variations in kernel length of barleys grown under different climatic conditions.

Spikes from three varieties, Wisconsin Barbless, Trebi, and Winter Club grown at Madison in 1942, were used to determine how the

kernels could best be chosen if picked from the spikes. Ten spikes were used in each sample, and only kernels from the central rows were used. One, two, three, or four seeds were picked from the middle part of each spike, and this gave samples of 10, 20, 30, or 40 seeds on which measurements were made. The length was measured from the base to the point where the awns break over the tip of the caryopsis in both threshed and unthreshed samples (table 50). The results

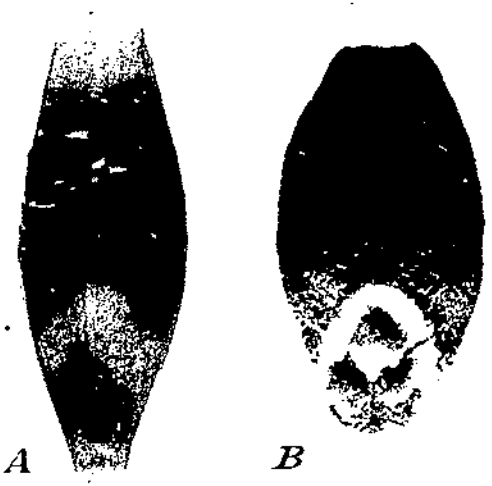


FIGURE 24.—Kernel types: *A*, Covered; *B*, naked.

show that a 10-kernel sample suffices if each kernel comes from a different spike. The determination of kernel length of threshed grain requires larger samples. The Wisconsin Barbless variety was used to determine the necessary sample size. Seeds of this variety, harvested in 1941 at Madison, Davis, and Bozeman, were measured. Samples consisting of 10, 20, 30, 40, 50, and 60 kernels from the central rows were measured from the Madison material, and 40 and 50 kernel samples from Davis and Bozeman. The Madison measurements had indicated that either the 40- or 50-kernel samples would be most

TABLE 50. *Results of kernel-length measurements in Wisconsin Barbless, Trebi, and Winter Club from Madison, 1942*

Number of kernels	Kernel length		
	Wisconsin Barbless	Trebi	Winter Club
	Mm.	*Mm.*	*Mm.*
10	7.48±0.117	8.50±0.373	8.54±0.381
20	7.41± .336	8.91± .141	8.77± .525
30	7.65± .205	8.81± .105	8.69± .549
40	7.59± .322	8.83± .169	8.69± .175

desirable. Six replications were used in all cases. The results shown in table 51 indicate that a sample of 40 kernels is satisfactory for the kernel-length determination of threshed grain.

For the study of variations in kernel length of barley grown under different climatic conditions, threshed samples of two varieties, Wisconsin Barbless and Manchuria (C. I. 2330), from three stations, Fargo, Bozeman, and Lincoln, from each of the years 1940, 1941, and 1942 were measured during the winter 1942–43. Each lot comprised three 40-kernel samples from the central rows of the spike. The measurements are given in table 52 and the statistical analyses in table 53.

TABLE 51.—*Kernel-length determinations on threshed samples of Wisconsin Barbless grown in 1941*

Number of kernels	Kernel length					
	Madison, Wis.		Davis, Calif.		Bozeman, Mont.	
	Average of 6 replications	Difference between high and low	Average of 6 replications	Difference between high and low	Average of 6 replications	Difference between high and low
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
10	7.16	0.61				
20	7.28	.51				
30	7.25	.43				
40	7.14	.31	7.15	0.51	6.96	0.26
50	7.14	.20	7.17	.45	6.92	.39
60	7.15	.31				

TABLE 52.—*Kernel-length measurements*

Variety and station	Averages of three 40-kernel samples		
	1940	1941	1942
	Mm.	*Mm.*	*Mm.*
Wisconsin Barbless:			
Fargo	6.96	7.20	6.65
Bozeman	7.17	6.95	7.08
Lincoln	7.18	7.20	7.41
Manchuria (C. I. 2330):			
Fargo	6.74	7.08	7.16
Bozeman	7.33	7.11	7.03
Lincoln	7.11	7.44	7.14

TABLE 53.—*Statistical analyses of kernel-length measurements recorded in table 52*

Item	Degrees of freedom	Sum of squares	Mean square	*F* value
Replications	2	0.0206	0.0103	1.26
Stations	2	.6075	.3488	[1] 38.64
Years	2	.0846	.0423	[2] 5.16
Varieties	1	.0204	.0204	2.49
Replications × stations	4	.0064	.0016	5.43
Replications × years	4	.0089	.0022	3.73
Replications × stations × years	8	.0313	.0039	2.10
Stations × years	4	.4814	.1204	[1] 14.68
Stations × varieties	2	.0365	.0183	2.23
Years × varieties	2	.0465	.0233	2.84
Stations × years × varieties	4	.6704	.1676	[1] 20.44
Error	18	.1469	.0082	
Total	53	2.2513		

[1] Highly significant. [2] Significant.

It is evident from table 53 that there is a highly significant difference between stations and a significant difference between years. The difference between replications and varieties was not significant. The two varieties differed only slightly in length, however, as shown in table 52. It is also clear from the data that when kernel length is used as a character in identifying barley, it is necessary to consider the climatic conditions under which the barley was grown. Allowances for variations caused by environment are necessary, and, therefore, kernel length will be a good character only if marked differences in length exist. In other cases it will serve as a minor character.

Additional data to support this opinion were obtained during 1943 and 1944. These data, obtained by using one kernel each from 10 spikes for each station, are given in table 54. The overlapping be-

TABLE 54.—*Kernel length*

SPRING VARIETIES (119)

Station	Year	Group 1 (short): <8.5 mm.	Group 2 (short to midlong): 8.5-9.2 mm.	Group 3 (midlong): 9.2-9.8 mm.	Group 4 (midlong to long): 9.8-10.5 mm.	Group 5 (long): >10.5 mm.
		Mars	Wisconsin Barbless	Tregal	Horsford	Club Mariout
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Ottawa	1943	8.5	8.8	9.5	10.3	10.5
Madison	1943	9.0	9.5	10.0	10.7	11.6
Aberdeen	1943	8.4	9.0	9.3	9.9	10.8
Do	1944	8.0	8.1	9.0	9.5	10.1
Sacaton	1943-44	8.2	8.4	9.1	9.8	10.1
Varieties represented, number		1	15	40	28	35

WINTER VARIETIES (69)

Station	Year	Awnless	Sunrise	Tennessee Winter (C. I. 257)	Texan	Bulgarian
		Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*
Raleigh	1942-43	8.7	9.6	10.3	10.2	11.4
Knoxville	1942-43	.....	8.4	9.0	9.3	10.2
Beltsville	1942-43	.....	8.4	9.1	9.4	10.0
Denton	1942-43	7.9	8.1	9.2	9.9	10.9
Sacaton	1943-44	7.1	9.0	9.4	10.1	10.5
Aberdeen	1944	7.8	8.7	9.4	8.9	10.5
Varieties represented, number	.....	1	3	37	17	11

tween the figures for the three groups "short to midlong," "midlong," and "midlong to long" shows that length of kernels has a limited use when closely related material is to be separated. If the material is grown under the same environment, it can most often be separated into 4 or 5 groups as to kernel length, but the small differences between these groups lose their significance under different environments. The only safe way to use kernel length in a taxonomic scheme for varieties from different locations is to choose differences in length that are definitely significant.

GERM LENGTH

The germ length is the distance from the base of the germ to the edge of the scutellum. The relationship of germ length to kernel

length is 1 to 3.5 for most varieties but may be quite different in some others. In order to find such cases a study was undertaken on the technique for making these measurements, using the same spikes and kernels of Wisconsin Barbless, Trebi, and Winter Club as were used for the kernel-length study. The results are given in table 55. Ten kernels are sufficient for a germ-length determination if the kernels are picked one each from 10 spikes and from the central row in the middle part of the spike.

Samples of 40 kernels are sufficient for germ-length determinations when threshed grain is used, as shown in table 56. The tests used for determining the best sample size for germ length were similar to the ones used for kernel length. Consequently, the same sampling technique as applied for kernel length also can be used here. In studying the germ length of the varieties in the classification nurseries in 1943 and 1944, samples of 10 kernels were used by taking one from each of 10 different spikes. The results are given in table 57.

Only a few varieties have germ lengths differing from the normal length of 2.5 to 3 millimeters. These few exceptions, however, indicate that significant differences in germ length might be found in a large collection of diverse origin.

The relationship between germ length and kernel length given above as 1 to 3.5 is confirmed by the data in tables 57 and 54. The "short" and "short to midlong" groups of kernels among the winter barleys also have a short germ, as indicated by the observations on Esaw and the group it represents. Among the other winter barleys and among the spring barleys, however, this relationship is not so apparent. It is concluded that germ length is of very limited use as a taxonomic character.

TABLE 55.—*Germ-length measurements in Wisconsin Barbless, Trebi, and Winter Club from Madison, 1942*

Number of kernels	Germ length		
	Wisconsin Barbless	Trebi	Winter Club
	Mm.	*Mm.*	*Mm.*
10	2.52±0.160	2.55±0.259	2.62±0.175
20	2.52± .150	2.66± .173	2.74± .225
30	2.51± .115	2.71± .237	2.68± .192
40	2.47± .202	2.68± .379	2.63± .246

TABLE 56.—*Germ-length determinations on threshed samples of Wisconsin Barbless grown in 1941*

Number of kernels	Madison, Wis.		Davis, Calif.		Bozeman, Mont.	
	Average of 6 replications	Difference between high and low	Average of 6 replications	Difference between high and low	Average of 6 replications	Difference between high and low
	Mm.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
10	2.57	0.36				
20	2.57	.17				
30	2.55	.18				
40	2.51	.19	2.49	0.13	2.44	0.26
50	2.46	.11	2.42	.05	2.45	.20
60	2.49	.21				

TABLE 57.—*Germ-length determinations*

SPRING VARIETIES (119)

Station	Year	Group 1 (<2.5 mm. long): Hannchen (C. I. 531)	Group 2 (2.5 to 3.0 mm. long): Atlas	Group 3 (>3.0 mm. long): Manchuria (C. I. 2330)
		Mm.	*Mm.*	*Mm.*
Madison	1943	2.6	2.6	3.2
Aberdeen	1943	2.3	2.8	3.2
Varieties represented.....number.	.....	3	111	5

WINTER VARIETIES (69)

Station	Year	Esaw	Tennessee Winter (C. I. 257)	Fayette
		Mm.	*Mm.*	*Mm.*
Raleigh	1942–43	2.4	2.8	3.3
Beltsville	1942–43	2.3	2.5	3.1
Knoxville	1942–43	2.5	2.8	3.0
Denton	1942–43	2.2	2.6	2.8
Varieties represented.....number.	.....	5	63	1

SHAPE OF KERNELS

The difference in the shape of kernels of six-rowed as compared with two-rowed varieties is very useful (figs. 25 and 26), and especially so when identifications must be made from threshed grain. In two-rowed varieties all the kernels are symmetrical in shape when viewed from the dorsal or ventral side, whereas in six-rowed varieties one-third (central kernels) are symmetrical and two-thirds (lateral kernels)

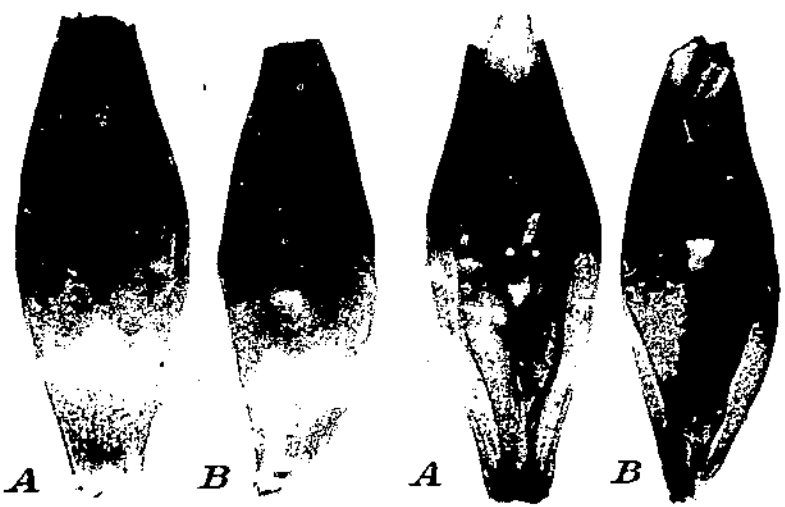


FIGURE 25.—Shape of kernels of six-rowed barley: *A*, Symmetrical, central rows; *B*, twisted, lateral rows.

are twisted. The twist is most noticeable at the attachment end and somewhat less so at the distal end.

Other kernel-shape characters are of minor importance, as most of them are highly variable because they are markedly influenced by climate and nutrition. Thickness and width are such characters. The kernels of Davidson, however, are typically wide and plump, and those of Perth are very slender and thin

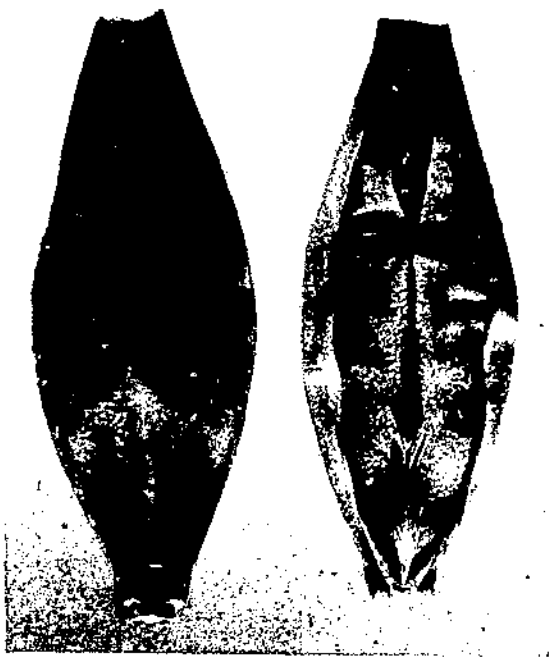


FIGURE 26.—Shape of kernels of two-rowed barley.

LEMMA-BASE SHAPE

The use of lemma-base shape to distinguish varieties, otherwise than as a supplementary varietal character, was not considered advisable by Åberg in 1940 (*1*), but further tests as to the value of this character were suggested.

The character was observed closely in the present study, but unfortunately most of the varieties belong in one or the other of the two groups, originally called *nutans* and *erectum*. These two names are very misleading for this character, and they are not applied here. Neither is the term "horseshoe-shaped depression" used. The depression at the lemma base in the group formerly called nutans has been incorrectly described as horseshoe-shaped. Its shape and appearance vary with varieties. It is evident now that its variability will increase as plant breeders continue to produce new varieties. In what formerly was called the erectum group the lemma-base shape can be described as having a transverse crease, the old character for

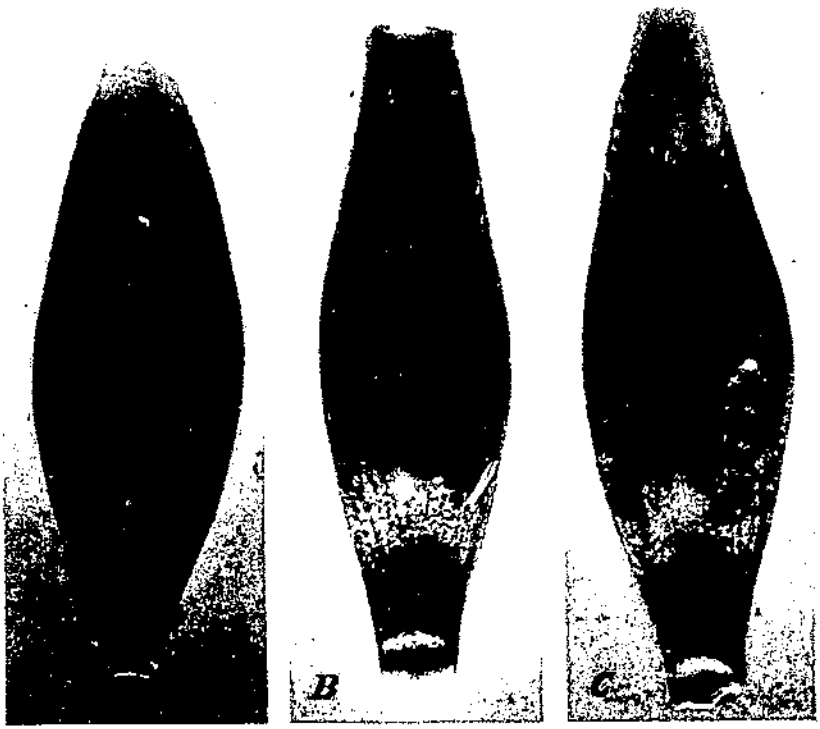


FIGURE 27.—Lemma-base shape: *A*, Transverse crease; *B*, depression tending to crease; *C*, depression.

TABLE 58.—*Lemma-base shape*

[D, Depression; C, transverse crease]

SPRING VARIETIES (119)

Station		Year	Group 1 (depression) Arnautka	Group 2 (depression tending to crease) Hero	Group 3 (transverse crease) Chile Marroni
Madison		1913	D	D	C
Aberdeen		1913	D	C	C
Varieties represented	number		107	8	4

WINTER VARIETIES (69)

Station		Year	Davidson	Tucker	Winter Club
Raleigh		1912-13	D	C	C
Knoxville		1912-13	D	D	C
Beltsville		1912-13	D	D	C
Denton		1912-13	D	D or C	C
Varieties represented	number		29	6	1

this group. Consequently, in the present study a distinction is made between a lemma base with a depression and that with a transverse crease. There are, however, several varieties that are intermediate

between these two types and are described as having a lemma base with depression tending to crease. Table 58 shows the grouping made on observations among the present material and figure 27 illustrates the three types—depression, depression tending to crease, and transverse crease.

Lemma Teeth and Hairs

The system of classifying barley kernels with the help of lemma teeth became popular with Neergaard (*16*), Atterberg (*5*), and Bolin (*9, 10*). They clarified the taxonomic value of the number of teeth on the lemma nerves, but apparently did not realize the variability in the character due to environment.

In the present study the number of teeth on the lemma nerves was determined on material grown in several climates. The number of teeth was observed on all five nerves of the lemma, which were labeled midnerve, lateral nerves, and marginal nerves, as shown in figure 28. Teeth were found on the midnerve in only the two varieties, Sunrise and Nakano Wase. The groups established for the number of teeth on the lateral and marginal nerves are given in table 59. It is evident from the data that teeth develop to a greater degree in the dry climate of Idaho and Arizona than in the humid climate of Wisconsin. These observations are in agreement with those made on smooth and semismooth awns. If the teething of lemma nerves is to be used with safety, observations must be made under a sufficient number of environments. This will be even more necessary with new varieties developed by hybridization.

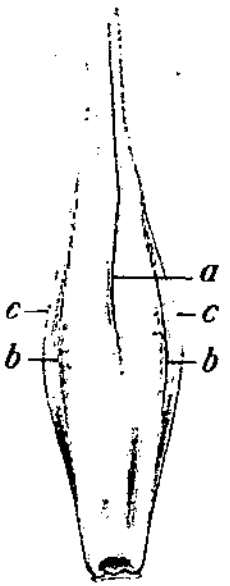


FIGURE 28. Dorsal view of kernel showing lemma nerves: *a*, Midnerve; *b*, lateral nerves; *c*, marginal nerves.

The four principal types of teething on lemma nerves are shown in figure 29. Hairs on the lemma were found only in Sunrise and Nakano Wase. In these varieties hairs were present both on the nerves and in the area between the nerves, as shown in figure 30.

Wrinkling of Hulls

Wrinkling of hulls is a heritable character, but its expression is highly dependent on environment, and this results in some overlapping in a system of grouping, as shown in table 60. Consequently, the taxonomic value of the character is limited, and the gradual change from one type to another must be kept in mind whenever the character is used. Grain left in the field until fully ripe shows more wrinkling than that which is harvested and threshed prematurely. The different degrees of wrinkling of the hulls are shown in figure 31.

TABLE 59.—*Teeth on lemma nerves*

[M, Numerous teeth; S, several teeth; F, few teeth; N, no teeth. The first symbol in each combination refers to the extent of teeth on lateral nerves, the second one to the extent on marginal nerves]

SPRING VARIETIES (19)

Station	Year	Group 1 (numerous teeth on lateral and marginal nerves): Manchuria (C. I. 2330)	Group 2 (numerous teeth on lateral and marginal nerves): Trebi	Group 3 (numerous teeth on lateral nerves, several on marginal): Meloy	Group 4 (several to numerous teeth on lateral and marginal nerves): Chevron	Group 5 (several teeth on lateral nerves, few on marginal): Olli	Group 6 (few teeth on lateral and marginal nerves): Afghanistan	Group 7 (few teeth on lateral nerves, none on marginal): Velvon	Group 8 (no to few teeth on lateral nerves, few to several on marginal): Hannchen	Group 9 (no teeth on lateral and marginal nerves): Horn	Group 10 (teeth on lateral and marginal nerves varying from none to numerous): Prospect
Madison	1943	MM	SS	MF	SS	SF	FF	NN	FF	NN	N to M
Aberdeen	1943	MM	MF	MM	MM	SF	FF	FN	NS	NN	N to M
Do	1941	MM	MM	MM	MM	SF	FF	FN	NS	NN	N to M
Saraton	1943-41	MM	MS	MS	MM	MS	SS	FN	FF	NN	N to M
Varieties represented	number	46	5	6	5	17	3	23	7	4	3

WINTER VARIETIES (60)

Station	Year	Tennessee Winter (C. I. 255)			Winter	Smooth Awn 86		Jackson 1			Kentucky 11
Raleigh	1942-43	MM			MM	SF		FN			N to M
Beltsville	1942-43	MM			MS	MF		FN			N to M
Knoxville	1942-43	MM			SS	SN		FN			N to M
Denton	1942-43	MM			SS	FF		FN			N to M
Saraton	1943-44	MM			MM	SF		FN			N to M
Aberdeen	1944	MM			MS	SF		FN			N to M
Varieties represented	number	46			7	10		5			1

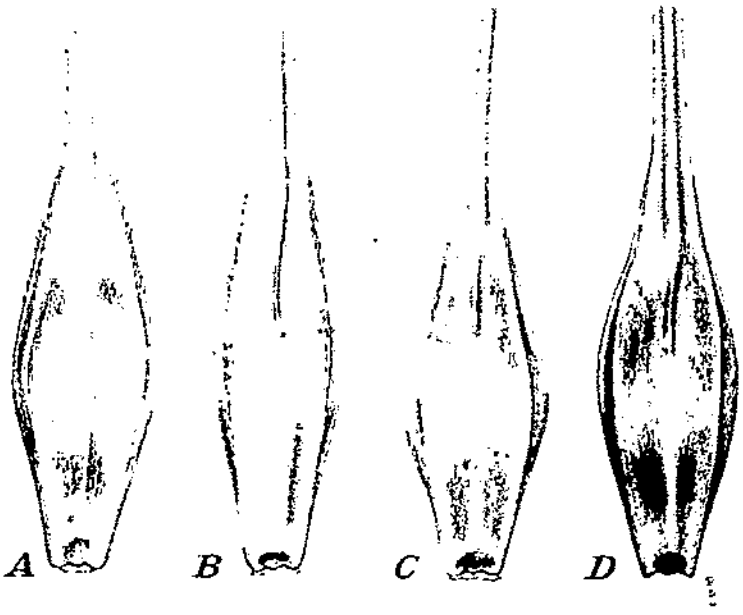


FIGURE 29. Lemma teeth: *A*, Numerous; *B*, several; *C*, few; *D*, none.

FIGURE 30.—Lemma hairs.

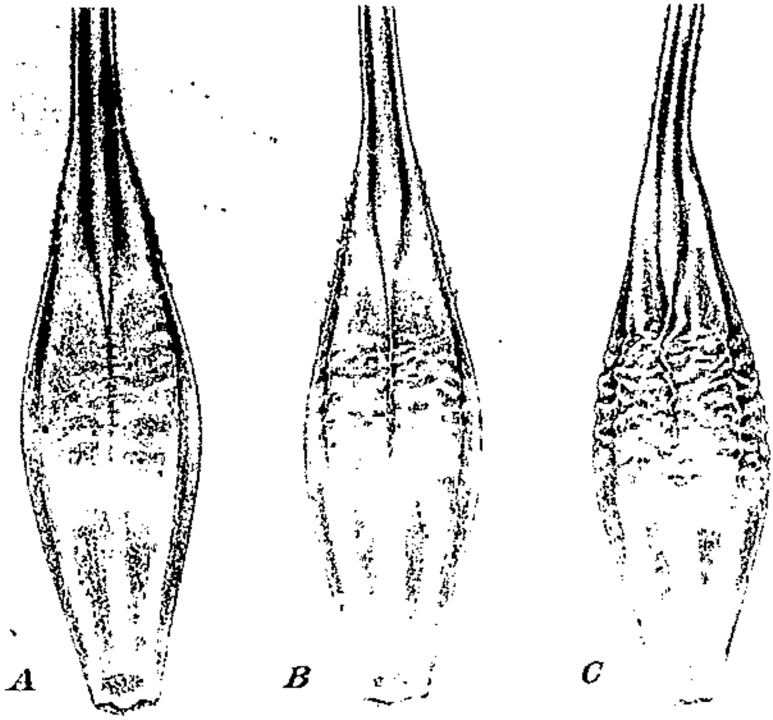


Figure 31.—Wrinkling of hulls: *A*, Slightly wrinkled; *B*, semiwrinkled; *C*, wrinkled.

Table 60.—*Wrinkling of hulls*

[SLW, slightly wrinkled; SW, semiwrinkled; W, wrinkled]

SPRING VARIETIES (119)

Station	Year	Group 1 (slightly wrinkled): California Mariout	Group 2 (slightly wrinkled to semiwrinkled): Rojo	Group 3 (semiwrinkled): Gebore	Group 4 (semiwrinkled to wrinkled): [illegible]	Group 5 (wrinkled): Hannchen
Madison	1913	SLW	SLW	SW	SW	W
Aberdeen	1915	SLW	SW	SW	W	W
Sacaton	1913–14	SLW	SW	SW	SW	W
Varieties represented — number		1	71	7	[illegible]	2

WINTER VARIETIES (60)

Station	Year	Tennessee [illegible]	Marno-barb	Tennessee Beardless 5	Nassau	[illegible] Hooded 3
Raleigh	1912–13	SLW	SLW	SW	SW	W
Sacaton	1913–14	SLW	SW	SW	W	W
Denton	1913–14	SLW	SLW	SW	SW	W
Aberdeen	1914	SLW	SW	SW	W	W
Varieties represented — number		1	12	2	42	3

Rachilla Hairs

The length of the hairs on the rachilla is one of the most stable characters for identifying barleys and is useful both in spike material and in threshed grain samples. The distinction between long and short hairs is easy to make in practically all cases. Of the varieties observed in this study only one, Smooth Awn 88, had hairs intermediate between long and short. Some varieties, however, are genetic mixtures of long- or short-haired plants. Such varieties usually originated as foreign introductions, mass selections, or plant selections made in an early hybrid generation.

Table 61 shows the distribution of the varieties that have short, short or long, and long hairs on the rachilla. Long- and short-haired rachillas are illustrated in figure 32.

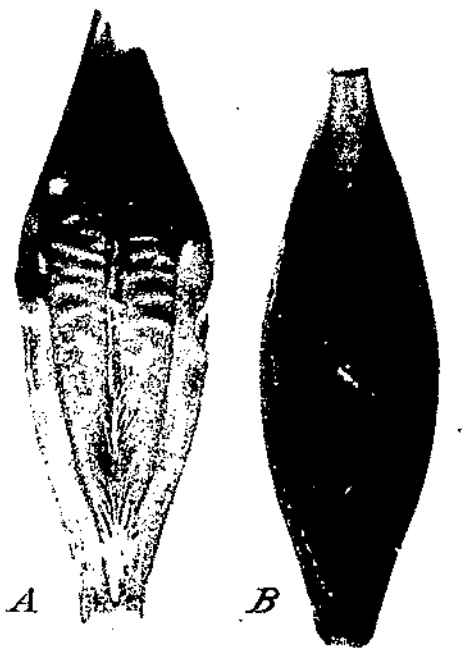


FIGURE 32.—Rachilla hairs: *A*, Long; *B*, short.

Rachilla Abortion

Abortive rachillas are rare, and no variety is pure for this character. Abortive rachillas are distributed more or less at random between and within the spikes of a variety, and they may vary from a trace in some varieties to as high as 50 percent in others. The variation within a variety may be induced in part by environment. This character can be used in identifying varieties when the extent of abortion is large, but can be used only as a minor character when it is small. Among the varieties included in the present investiga-

tion, only 13 percent of the spring and 9 percent of the winter varieties showed aborted rachillas. The type of abortion found in the varieties studied is shown in figure 33, and the distribution is given in table 62.

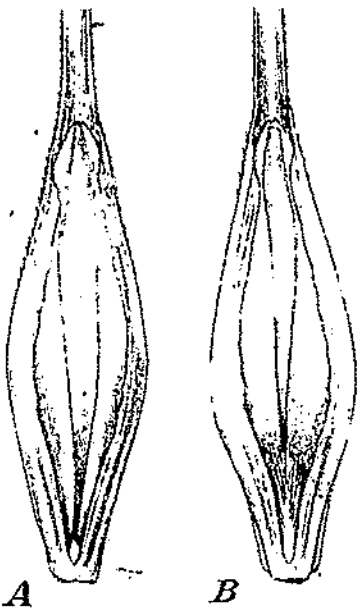


FIGURE 33.—Rachilla abortion: *A*, Abortive; *B*, normal.

LENGTH OF RACHILLA

Bell and Carson (*7*) showed in 1941 that length of rachilla is a varietal character but is strongly affected by environmental factors. They also showed that in six-rowed barleys the rachilla is longer in the lateral spikelets than it is in central ones. The observations on the varieties in this bulletin are in agreement with those of Bell and Carson (*7*), although the majority of the varieties fall in the midlong rachilla-length group. Three groups are recognized—long, midlong, and short—as shown in table 63.

KERNEL COLORS

The background of kernel colors was extensively discussed by Harlan (*12*) in 1914. He pointed out that there are two primary pigments in barley—anthocyanin and a melaninlike compound. Anthocyanin is red in an acid and blue in an alkaline medium. It is red in the hulls and pericarp but blue in the aleurone layer of the kernel. Naked kernels with anthocya-

TABLE 61.—*Hairiness of the rachilla*

[S, Short-haired; L, long-haired]

SPRING VARIETIES (69)

Station	Year	Group 1 (short-haired): Atlas	Group 2 (short- or long-haired): Pontiac	Group 3 (long-haired): Chilron
Madison	1913	S	S or L	L
Aberdeen	1913	S	S or L	L
Do.	1914	S	S or L	L
Saenton	1911	S	S or L	L
Varieties represented..... number		37	3	29

WINTER VARIETIES (69)

Station	Year	Randolph	Reno	Olympia
Raleigh	1912	S	S or L	L
Knoxville	1942	S	S or L	L
Beltsville	1942	S	S or L	L
Denton	1912	S	S or L	L
Saenton	1913-14	S	S or L	L
Aberdeen	1911	S	S or L	L
Varieties represented..... number		19	9	11

TABLE 62.—*Percentage of abortive rachillas*

SPRING VARIETIES (119)

Station	Year	Group 1 (25 to 50 percent abortive): Compana	Group 2 (occasionally abortive): Spartan	Group 3 (none abortive): Ezond
		Percent	*Percent*	*Percent*
Madison	1943	20	10	0
Aberdeen	1943	10	0	0
Do	1944	30	10	0
Sacaton	1943–44	55	10	0
Varieties represented, number		10	7	102

WINTER VARIETIES (60)

Station	Year	Smooth Awn 86	Davidson
Madison	1942–43	0	0
Do	1943	6	0
Raleigh	1942–43	0	0
Beltsville	1942–43	0	0
Denton	1942–43	0	0
Sacaton	1942–43	20	0
Varieties represented, number		7	62

TABLE 63. *Length of rachilla*

SPRING VARIETIES (119)

Station	Year	Group 1 (long): Vance	Group 2 (midlong): Manchuria (C. I. 2330)	Group 3 (short): White Smyrna
		Mm.	*Mm.*	*Mm.*
Madison	1943	4.7	3.7	2.7
Aberdeen	1943	4.4	3.3	2.9
Varieties represented, number		4	100	15

WINTER VARIETIES (69)

Station	Year	Randolph	Jackson	Esaw
		Mm.	*Mm.*	*Mm.*
Raleigh	1942–43	4.8	3.9	2.5
Beltsville	1942–43	3.9	3.8	2.3
Knoxville	1942–43	4.9	3.3	2.2
Denton	1942–43	4.0	3.4	2.1
Varieties represented, number		10	53	6

nin in both pericarp and aleurone are purple. When the melaninlike compound is present in the hulls or pericarp, these tissues are black, gray, or brown, depending on the intensity of the deposit. The color due to the melanin compound usually masks any blue aleurone color present, so that the pericarp must be removed before the aleurone color can be determined.

Color of Lemma and Palea

The lemma and palea are black in certain varieties, including Dorsett, Lion, and Blackhull, and the color remains constant even under varying climatic conditions. A slight tinge of purple can be detected in the lemma of Munsing at some locations, and this is a useful observation for this variety. In most varieties, however, the lemma is yellow. Anthocyanin may or may not be present in the lemma nerves, and its expression at this point is highly variable, as shown in table 64. Very few varieties are without colored nerves, and only a moderate number have strongly colored ones. Most varieties have slightly colored nerves, and this character is highly variable.

TABLE 64.—*Colored lemma nerve*

[A, Absence of color; P, presence of color in moderate quantities; S, presence of color in abundance]

SPRING VARIETIES (115)

Station	Year	Group 1 (nerves without color): Const	Group 2 (nerves slightly colored): Glacier	Group 3 (nerves slightly colored): Ezond	Group 4 (nerves slightly colored): Vaughn	Group 5 (nerves slightly colored): Wisconsin Barbless	Group 6 (nerves colored): Galore	Group 7 (nerves colored): Rojo
Madison	1943	A	A	A	P	P	S	S
Saeaton	1943–44	A	P	P	P	S	S	S
Aberdeen	1944	A	A	P	P	P	P	S
Varieties represented, number		29	31	19	12	15	8	1

WINTER VARIETIES (69)

Station	Year	Kirwin	Purdue 21	Kentucky 6	Randolph	Purdue 28154–A3-1-1-6	Texan	Marmoberb
Raleigh	1942–43	A	A	P	P	P	S	S
Beltsville	1942–43	A	A	P	P	P	S	S
Knoxville	1942–43	A	A	P	P	P	S	S
Saeaton	1943–44	A	P	P	P	S	P	S
Aberdeen	1944	A	P	A	P	S	S	S
Varieties represented, number		20	16	11	7	11	3	1

Color of Caryopsis

The color of the caryopsis is actually the combined effect of color in the aleurone and pericarp. The differences in caryopsis color in the present material are based largely upon aleurone color, as the number of black varieties is small. Of the hulled black varieties, Dorsett and Blackhull have black color in the pericarp that covers the blue aleurone.

Color of Aleurone

The color of aleurone is influenced to a very high degree by climatic conditions. It is very difficult to separate blue aleurone from white in kernels produced under humid conditions, especially if the blue

color is of a low intensity. Under arid conditions, however, separations of blue and white color are easily made, and here it is even possible to distinguish three or four shades of blue. The value of aleurone color for classification purposes is, therefore, greatly restricted except for barley grown in dry areas. Observations on the aleurone color are given in table 65. At Sacaton and Aberdeen, different shades of blue could be distinguished from each other and from white, but in barley grown at Madison and Fargo the only possible separation was blue from white and sometimes this was accomplished with difficulty.

TABLE 65.—*Aleurone color*

[W, White; B, blue; B1, light blue; B2, medium blue; B3, dark blue]

SPRING VARIETIES (119)

Station	Year	Group 1 (white): Wisconsin Barbless	Group 2 (white or blue): Glabron	Group 3 (blue): Montcalm	Group 4 (blue): O. A. C. 21	Group 5 (blue): Trebi
Madison	1943	W	B or W	B	B	B
Fargo	1943	W	B or W	B	B	B
Sacaton	1943–44	W	W or B1	B1	B2	B3
Aberdeen	1944	W	W or B2	B1	B2	B3
Varieties represented...number		69	12	14	18	6

WINTER VARIETIES (69)

Station	Year	Randolph	Tennessee Winter (C. I. 257)	Michigan Winter	Cascade	Nassau
Raleigh	1942–43	W	B or W	B	B	B
Sacaton	1943–44	W	B1 or W	B1	B2	B3
Aberdeen	1944	W	B2 or W	B1	B2	B3
Varieties represented...number		21	8	28	10	2

WIDTH AND DEPTH OF VENTRAL CREASE

In wheat the width and depth of the ventral crease of the kernel has a certain value for classification, according to Clark and Bayles (*11*). Both characters were studied in barley but proved to be of no value, because their expression depended too much upon nutritional and environmental factors.

KERNEL WEIGHT

The kernel weight was determined according to the Shands' (*17*) technique, that is, by weighing a sample of 400 kernels and giving the average weight of a single kernel in milligrams. Kernel weight varies widely and it can be used only as a descriptive character. The distribution of the weights within this material is found in table 66.

TABLE 66.—*Kernel weight*

SPRING VARIETIES (119)

Station	Year	Group 1 (25 to 30 mg.): Peatland	Group 2 (30 to 35 mg.): Manchuria (C. I. 2330)	Group 3 (35 to 40 mg.): Franklin Malt	Group 4 (40 to 45 mg.): California Coast	Group 5 (45 to 50 mg.): Flynn
		Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Madison	1943	28.4	33.6	35.0	42.2	49.5
Aberdeen	1943	30.9	36.1	39.1	49.0	52.1
Sacaton	1943–44	24.5	30.8	36.5	43.7	46.7
Varieties represented—number		4	29	38	36	22

WINTER VARIETIES (60)

Station	Year	Awnless	Reno	Olympia	Jackson 1	Bulgarian
		Mg.	*Mg.*	*Mg.*	*Mg.*	*Mg.*
Raleigh	1943	28.9	32.1	39.2	41.4	45.8
Sacaton	1943–44	27.0	29.5	40.0	43.5	45.1
Denton	1944	26.2	36.0	38.6	41.2	46.0
Varieties represented—number		2	26	32	7	2

DISCUSSION

This discussion is limited to some of the present trends apparent in the classification of cultivated plants. Early workers determined the value and stability of a number of characters, and the present study confirms these earlier findings. The earlier workers also recognized that other characters were less stable and of little value in classification and made little or no use of them. Since the number of usable characters is limited and new ones arise largely by chance, the modern trend is to make the best possible use of all observable characters, even those not entirely stable under all conditions. A new basis must be established to evaluate these characters. This consists of studying them at a number of stations and in different years to determine the variability of the character due to environment. If a large number of variable characters are studied and the limits of usefulness are established for each, it is then possible to use them in identifying varieties. The expression of many characters varies through a continuous series and only the extreme types can be distinguished with certainty. Unfortunately, the number of varieties that can be separated with certainty often is small.

It is important to keep in mind that the material to be classified is living material. By giving full credit and attention to the numerous varying characters as well as to the stable ones, a more complete description is possible; and the summary effect of combining stable and variable characters will be such as to give a total impression that will best fit its description.

Some varieties are mixed for certain characters, such as blue and white seeds or long- and short-haired rachillas, although the characters themselves are completely stable and breed true. Such mixed characters when originally present must be considered as typical of the variety. Often it is possible to identify a variety by just such a mixture when it is known that the mixture is a natural condition. The extent to which mixed characters can be used as a characteristic of a

variety will depend on a knowledge of the history of the variety and on proof that the component parts of the mixture are definite entities and not merely wide fluctuations of the same character.

Some characters that appear to be mixed cannot be classed in the above category. For example, abortive rachillas occur consistently as mixtures in certain varieties, but the types do not breed true. Normal and abortive rachillas can be found side by side in the same spike, but the percentage of each is greatly influenced by environment. There are two fundamental differences between mixtures of this kind of character and the one in the preceding paragraph, namely, (1) in the mixture discussed here, the character in its several modes of expression can be found on the same plant, whereas in the former case it is always limited to separate plants, (2) lines cannot be selected that will breed true for the character in the mixtures in the case discussed here but will breed true for the characters in the case above.

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APPENDIX

The four tables 67 to 70 serve as summary, or reference, tables for finding the varieties that belong in the character groups given in the earlier tables; or conversely, for finding the characteristics of a particular variety. Table 71 gives a schematic summary of the taxonomic value of the characters discussed and the degree to which each is influenced by environment. The information in this table is based on the varieties used and on the environmental conditions present at the stations during the years they were studied. These varieties are a special group, consisting almost entirely of the commercial varieties of the United States and Canada. For this reason the taxonomic value assigned to any particular character may not be the same if a less select group were studied. The environmental influences are evaluated to such a degree that no substantial differences would be likely to be found if another group of varieties were studied.

TABLE 67.—*Distribution of spring barley data by character groups in tables 5 to 31*

Varieties	C. I. No.	Table																										
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26	27	28	29	30	31
Afghanistan	4173	2	1	4	3	2	1	3	2	2	2	2	2	2	3	2	5	2	1	1	3	1	2	4	2	2	2
Alpha	959	1	4	2	3	8	1	1	2	2	3	3	1	1	3	4	3	3	2	1	1	1	2	2	5	2	2
Arivat	6573	2	1	2	3	2	6	3	2	2	2	3	1	1	2	1	1	2	1	1	2	1	1	5	5	2	2
Atlas	4118	1	1	2	3	2	3	1	2	2	2	4	2	1	3	1	1	2	1	1	2	1	1	5	4	2	2
Atlas × Vaughn (Moscow 8)	6971	2	1	2	3	2	6	3	2	2	2	4	1	2	2	1	2	2	1	1	2	1	1	5	5	2	2
Atsel	6250	1	1	3	3	6	3	3	2	1	2	4	2	1	3	1	3	2	1	1	3	1	1	6	4	2	2
Bay	7113	2	5	2	3	4	1	1	2	2	2	2	1	1	3	4	2	2	1	1	2	2	1	4	2	2	2
Bearer		1	5	2	3	6	1	1	2	1	2	3	1	1	2	5	3	2	1	1	2	1	1	4	4	2	2
Beecher	6566	2	1	2	3	2	6	3	2	1	2	4	1	1	2	1	1	2	1	2	2	1	1	5	5	2	2
Beldi Giant	2777	1	2	2	1	4	1	1	2	2	2	4	1	1	3	2	4	2	1	1	3	1	1	5	5	2	2
Belford	7060	1	3	2	1	5	1	1	2	1	2	2	1	1	3	3	4	1	1	1	2	1	1	5	3	2	2
Blackhull	878	1	1	2	1	2	1	3	2	1	1	3	1	1	3	2	2	2	1	1	1	1	2	3	5	2	2
Blue	1247	3	3	2	3	1	1	2	2	1	2	4	1	1	3	2	4	2	1	1	3	1	1	5	5	2	2
Brandon 216		1	5	2	3	5	1	1	2	2	2	3	1	1	3	3	1	3	2	1	1	3	1	5	3	2	2
Byng	6089	3	4	2	3	4	1	1	2	2	2	3	1	1	3	3	4	2	1	1	1	1	1	5	4	2	2
California Coast	6115	1	2	2	1	1	1	1	2	1	2	4	1	1	3	2	4	2	1	2	2	1	1	5	4	2	2
California Mariout	1455	1	1	2	3	4	1	1	2	2	2	4	3	1	3	1	4	2	1	3	1	1	2	4	1	2	2
Canadian Thorpe	740	2	4	2	3	4	1	3	2	2	2	3	1	1	3	5	3	3	3	1	1	1	2	4	4	2	2
Charlottetown 80	2732	1	5	2	3	4	1	1	2	2	2	2	1	1	3	4	1	2	1	1	2	1	1	4	3	2	2
Chevron	1111	1	5	2	3	7	1	1	2	2	2	4	1	1	3	1	5	2	1	2	2	1	1	6	5	2	2
C. I. 7008	7008	2	2	2	3	1	1	1	2	1	2	4	1	1	3	1	1	2	1	1	2	1	1	5	5	2	2
Club Mariout	261	2	1	2	3	2	1	1	2	2	2	4	1	1	3	1	5	2	1	2	2	1	1	6	6	2	2
Coast	690	1	3	2	3	1	1	1	2	2	1	4	1	1	3	2	4	1	1	1	2	1	1	5	5	2	2
Colsess	2792	1	2	2	3	6	1	1	2	2	2	3	2	1	3	3	2	2	1	1	1	1	1	4	4	2	2
Common Six-Row	4625	1	2	2	2	1	1	1	2	2	2	4	1	1	3	3	4	2	1	1	2	1	1	5	5	2	2
Common Six-Row (4307 M. C.)		1	4	1	3	5	1	1	2	2	2	1	2	1	3	1	4	2	1	1	2	1	1	4	4	2	2
Compana	5438	1	2	2	3	6	1	3	2	2	2	3	1	1	3	1	4	2	1	1	4	1	2	5	4	2	2
Composite Cross selection (36Ab, 109)	7155	2	4	2	3	4	1	1	2	1	2	4	1	1	3	2	1	2	1	1	3	1	1	5	5	2	2
Composite Cross selection	5449	1	4	2	1	5	1	1	2	2	2	4	1	1	3	4	3	2	1	1	3	1	1	5	5	2	2
Conway	6095	3	2	2	3	4	1	1	2	2	2	3	2	1	3	2	3	2	1	1	2	1	1	5	2	2	2
Dorsett	4821	1	1	3	3	8	2	2	1	1	2	1	2	1	3	2	3	2	1	1	3	1	1	4	2	2	3
Duplex		3	1	2	1	5	6	2	2	1	2	1	2	1	3	2	4	2	1	1	3	1	1	5	5	2	3
Ezond	6265	3	2	2	3	4	1	1	2	2	2	3	1	1	3	2	3	2	1	1	3	1	1	4	4	2	3
Ezond selection (Wyo. 111 38-17)		3	3	2	3	4	1	1	2	2	2	3	1	1	3	2	3	2	1	1	3	1	1	5	5	2	3
Flynn	1311	3	1	4	3	2	3	3	2	2	2	4	1	2	2	2	2	2	1	1	3	1	1	5	5	2	3
Flynn 1	5911	4	1	4	3	2	6	4	2	3	2	4	1	2	2	1	2	2	1	1	2	1	1	5	5	2	3
Flynn 37	5918	4	1	3	3	2	3	4	2	3	2	4	1	1	2	1	1	2	1	1	2	1	1	5	5	2	3
Flynn selection		4	1	3	3	2	3	4	2	3	2	4	1	1	2	1	1	2	1	1	2	1	1	5	5	2	3
Flynn × Vaughn		4	1	3	3	2	3	4	2	3	2	4	1	2	2	1	1	2	1	1	2	1	1	5	5	2	3
Franklin Malt	5915	1	3	2	3	3	1	1	2	1	2	3	1	1	3	1	5	3	1	2	1	1	1	5	4	2	2
Galore	7150	1	3	2	3	4	1	1	2	2	2	3	2	1	3	1	4	2	1	1	1	1	1	3	3	2	2
Gartons	7016	1	4	2	3	4	1	1	2	2	2	2	1	1	3	2	4	2	1	1	4	1	1	5	3	2	2
Glabron	4577	2	4	2	3	8	1	1	2	2	2	1	1	1	3	5	3	3	2	1	1	1	1	3	2	2	3

Glacier	6976	2	1	2	3	2	3	3	2	1	2	4	1	1	2	2	2	2	1	1	2	1	1	5	5	2	3
Goldfoil	928	1	5	2	3	4	1	3	3	2	3	3	2	1	3	3	3	3	2	1	3	1	2	3	5	2	2
Hannchen	531	1	5	2	3	5	1	3	3	3	3	3	1	2	3	4	3	3	2	1	3	1	2	2	5	2	1
Hero	4602	2	2	2	3	2	3	3	3	3	3	4	1	2	1	1	5	3	2	2	3	1	1	6	5	4	2
Horn	926	1	4	2	3	2	2	3	2	2	3	2	1	1	3	4	3	3	2	1	2	1	2	2	3	2	3
Horsford	1775	1	3	2	3	5	1	1	2	1	1	2	1	1	3	4	2	1	1	1	1	1	1	5	4	2	2
Hybrid Composite (Nebr. 381162)	7114	1	1	2	3	4	6	3	3	2	2	3	3	3	3	1	2	3	1	1	3	1	1	5	3	2	2
Hybrid Composite (Nebr. 381175)		3	1	3	3	2	1	3	2	2	3	3	1	2	2	1	3	3	2	1	2	1	1	5	4	2	4
Lico	6279	2	2	2	3	4	1	2	2	2	3	4	1	1	2	3	3	3	1	1	2	1	1	5	5	2	4
Lion	923	3	2	2	3	5	1	1	3	3	3	2	1	1	2	2	3	3	2	1	3	1	1	5	5	2	3
Manchuria	2330	1	3	2	3	8	1	1	2	2	2	2	1	1	3	4	3	2	1	1	1	1	1	3	2	2	3
Manchuria	2947	1	3	2	3	8	1	1	2	1	2	2	1	1	3	4	3	2	1	1	1	1	1	3	2	2	3
Manchuria	7151	1	3	3	3	3	1	1	2	2	2	1	1	1	3	4	3	2	1	1	1	1	1	3	3	2	2
Mars	7015	1	2	2	3	5	1	1	2	2	2	2	3	1	3	2	1	2	2	1	2	1	1	5	3	2	3
M. C. 8120		1	4	2	3	5	1	1	2	2	2	1	1	1	3	5	3	2	1	1	1	2	1	3	2	2	3
Meloy	1176	1	2	2	3	4	1	1	2	2	2	3	1	1	3	2	2	2	1	1	2	1	1	5	5	2	2
Meloy 3	4656	1	3	2	3	4	1	1	2	1	1	3	1	1	3	4	3	1	1	1	1	1	1	5	4	2	1
Mensury	4696	1	3	2	3	4	1	1	2	2	2	1	1	1	3	4	3	2	1	1	1	1	1	3	2	2	3
Mensury 32 (M. C.)		1	4	2	3	5	1	1	2	2	2	2	1	1	3	5	3	2	1	1	1	2	1	3	2	2	3
Mensury (Ott. 60)		1	3	2	3	4	1	1	2	2	2	2	1	1	3	5	3	2	1	1	1	1	1	3	2	2	3
Michigan Two-Rowed	2782	1	4	2	3	5	1	3	2	3	3	3	1	2	3	3	3	3	2	1	3	1	2	3	5	2	2
Minia	3556	3	1	3	3	1	1	1	2	1	2	4	1	1	3	2	5	2	1	2	3	1	1	6	4	2	1
Minn. II-31-19		1	1	1	3	5	1	1	2	2	2	2	3	1	3	2	1	2	2	1	2	1	1	5	3	2	3
Montcalm	7149	1	4	1	3	8	1	1	1	2	2	3	1	1	3	5	3	2	1	1	1	1	1	5	2	2	3
Munsing	6009	1	2	2	3	4	1	1	2	3	2	3	3	2	3	1	4	3	2	1	4	1	2	4	5	2	2
Newal	6088	1	4	2	3	4	1	1	2	2	2	3	3	1	3	4	4	2	1	1	1	1	1	3	3	2	3
Nobarb	6335	2	5	2	3	5	1	1	2	2	2	3	1	1	3	5	3	2	1	1	2	1	1	4	2	2	4
O. A. C. 21	1470	1	3	2	3	6	1	1	2	1	2	1	1	1	3	4	3	2	1	1	1	1	1	3	2	2	3
O. A. C. 35-2-0		2	5	2	3	8	1	1	2	2	2	3	1	1	3	5	3	2	1	1	3	1	1	4	2	2	2
Oderbrucker	4666	1	4	2	3	4	1	1	2	2	2	2	1	1	3	5	2	2	1	1	1	1	1	3	3	2	3
Odessa	182	1	4	3	3	3	1	1	2	2	2	2	1	1	3	3	5	2	3	1	2	1	1	5	4	2	3
Olli	6251	1	1	1	3	8	1	1	3	2	3	2	1	1	3	2	3	3	1	1	1	4	1	5	3	2	1
O. P. R. I		1	4	2	3	8	1	1	2	2	2	3	2	1	3	4	2	2	1	1	1	1	1	4	4	2	2
Peatland	5267	1	5	2	3	7	1	1	2	2	2	3	1	1	3	4	1	3	1	1	2	1	1	4	3	2	3
Peatland×Vaughn (S. Dak. 384)		1	4	2	3	4	1	1	2	2	2	2	1	1	1	3	2	2	1	1	2	1	1	3	5	1	3
Peatland×Vaughn (S. Dak. 317)		2	1	2	3	4	1	1	2	1	2	4	1	1	2	2	1	2	1	1	2	1	1	5	5	2	2
Perth	6025	3	1	4	2	1	5	4	2	2	2	3	2	2	3	1	4	2	1	1	3	1	1	5	1	3	1
Peruvian 19	6568	1	3	2	1	6	1	1	2	1	2	4	1	1	3	3	4	2	1	1	3	1	1	5	5	2	2
Plush	6093	3	5	2	3	5	1	1	2	2	3	2	1	1	3	4	2	2	1	1	1	1	1	4	3	2	2
Pontiac	4849	1	4	2	3	5	1	1	2	2	2	2	1	1	3	5	3	2	1	1	1	1	1	4	2	2	3
Prospect	6339	2	2	2	3	4	1	1	2	2	3	1	1	1	3	4	3	3	2	1	2	1	1	4	3	2	3
Queens	7021	1	5	2	3	4	1	1	2	2	3	3	1	1	3	3	3	2	2	1	2	4	2	4	5	2	1
Regal	5030	1	4	2	3	4	1	1	2	2	2	2	2	1	3	5	4	3	1	1	1	4	1	3	3	2	2
Rex	6618	1	4	2	3	4	1	3	3	3	3	2	2	2	3	4	1	3	2	1	2	1	2	3	3	2	2
Rojo	5401	3	1	2	1	2	6	3	3	2	3	3	1	2	2	2	3	3	2	2	2	1	1	5	5	3	3
Rufflyn	6374	1	3	2	3	4	1	1	2	1	3	4	1	1	3	2	4	2	1	1	2	1	1	6	5	2	2
Sanalta	6087	2	5	2	3	4	1	1	1	2	3	4	2	1	3	4	3	3	2	1	2	1	2	4	4	4	1
Scarab	995	1	3	2	3	5	4	2	2	1	1	2	1	1	3	1	3	2	1	1	3	2	1	6	3	4	1
Short Comfort	5907	2	3	2	3	4	1	1	3	2	2	2	1	1	3	4	2	3	1	1	2	5	1	4	3	2	2
Sixty Day	5031	1	1	2	3	6	1	1	3	3	2	2	1	1	3	4	2	3	1	1	1	1	1	5	3	2	2
Spartan	5027	1	1	2	3	4	1	3	2	3	3	3	1	1	3	3	1	3	2	1	2	1	2	4	4	2	1
Stavropol	5913	1	2	2	3	6	1	1	2	2	2	4	1	1	3	2	4	2	1	1	2	1	1	5	5	2	3
Steigum	907	1	4	2	3	4	1	3	3	3	3	2	1	1	2	3	4	2	3	1	1	1	2	3	3	2	3

TABLE 67.—*Distribution of spring barley data by character groups in tables 5 to 31*—Continued

Varieties	C. I. No.	Table																									
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26	27	28	29	30	31
Stephan		1	5	2	3	4	1	3	3	2	3	3	1	1	3	3	2	3	1	1	3	1	2	3	5	2	1
Tall Comfort	4578	1	4	2	3	5	1	1	3	2	2	3	2	1	3	5	3	2	2	1	1	4	1	3	2	2	3
Titan	7055	1	4	2	3	5	1	1	2	2	2	2	3	1	3	3	3	2	1	1	1	5	1	4	3	2	4
Trebi	936	3	3	2	3	3	1	1	1	1	2	3	1	1	3	1	3	2	1	1	3	1	1	4	4	2	2
Trebi × Regal	6358	1	3	2	3	4	1	1	2	2	2	3	1	1	2	3	3	2	1	1	3	1	1	3	5	2	3
Tregal	6359	2	3	2	3	4	1	1	2	2	2	3	1	1	3	2	2	2	1	1	2	1	1	5	4	2	1
Tunis	1383	2	1	4	3	4	1	1	2	1	2	4	1	1	2	1	4	2	1	2	2	1	1	5	4	2	2
Union Beardless	5976	1	4	4	1	5	1	1	2	1	2	4	1	1	3	3	3	2	1	1	1	1	1	5	5	2	2
Vance	4585	1	2	2	3	2	5	3	3	2	3	2	2	4	3	1	4	3	2	1	4	1	2	4	4	2	2
Vaughn	1367	4	1	3	3	2	6	4	2	2	2	4	1	2	2	1	1	2	1	1	2	5	1	5	5	2	2
Velvet	4252	1	3	2	3	3	8	1	1	2	3	2	2	1	3	4	3	3	2	1	2	4	1	3	3	2	2
Velvet × Trebi (Iowa sel. 15)	7118	2	5	3	3	8	1	1	2	2	2	3	1	1	3	4	3	3	2	1	2	4	1	4	3	2	2
Velvon	6109	2	2	2	1	4	1	1	2	1	3	4	1	1	2	3	3	3	1	1	2	1	1	4	5	2	2
Velvon 7		2	3	2	2	4	3	1	2	2	2	3	1	1	2	3	3	3	2	1	2	1	1	4	5	2	2
Velvon 11	7088	2	2	2	3	4	1	1	2	2	3	3	1	1	2	3	3	2	1	1	2	1	1	4	5	2	2
Warrior	6991	1	1	2	3	4	1	1	2	2	2	3	1	1	2	3	1	2	1	1	2	5	1	5	4	2	2
White Smyrna	910	1	2	2	3	4	1	3	2	1	2	3	2	2	2	1	4	2	1	1	4	1	2	3	5	2	2
Winter Tennessee	4633	1	3	2	1	6	1	2	2	2	2	4	1	1	2	1	3	2	1	1	3	1	1	5	4	2	2
Wisconsin Barbless	5105	2	4	2	3	8	1	1	2	2	3	1	1	1	3	5	3	3	2	1	2	1	1	1	2	1	2
Wisconsin 9	1275	1	4	2	3	8	1	1	2	2	2	3	1	1	3	4	3	3	1	1	2	1	1	4	3	2	2
Wisconsin H135-7-2-1-3	7115	1	5	2	3	5	1	1	2	2	2	2	1	1	3	5	2	2	1	1	2	1	1	3	3	2	2
Wisconsin H135-7-6-4-1	7116	1	5	2	3	5	1	1	2	2	2	2	1	1	3	5	2	2	1	1	2	1	1	3	3	2	2
Wisconsin H141-4-4-4-1		1	5	2	3	8	1	1	2	2	2	3	1	1	3	5	2	2	1	1	2	2	1	3	3	2	3

TABLE 68. *Distribution of spring barley data by character groups in tables 32 to 66*

Varieties	C. I. No.	Table																											
		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	54	57	58	59	60	61	62	63	64	65	66
Afghanistan	4173		2	5	2	2	3	1	4	1	1	5	1	2	2		1	1	3	4	2	1	6	4	3	3	2	3	4	4
Alpha	959		1	5	2	2	3	5	4	1	2	5	1	3	2		1	1	2	3	2	1	4	4	2	3	2	2	5	1
Arival	6573	3	3	5	1	3	3	9	2	1	1	4	1	2	2		1	3	3	5	2	1	2	2	3	1	3	4	1	5
Atlas	4118	1	3	5	1	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	1	1	3	2	3	5
Atlas × Vaughn (Moscow 8)	6971	2	3	5	1	3	3	9	2	1	1	4	1	2	2		1	3	3	5	2	2	2	2	1	3	3	2	3	5
Atsel	6250	2	3	5	2	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	3	2	1	3	2	3	3	4
Bay	7113	6	1	5	3	1	3	9	1	2	2	1	1	4	4		2	2	1	2	2	1	3	2	3	3	3	1	2	
Bearer		4	1	5	2	1	3	1	3	1	2	5	1	2	2		1	1	1	2	2	1	10	2	1	3	2	3	2	1

Beecher	6566	4	3	5	1	3	3	9	2	1	1	4	1	2	2	...	1	3	3	5	2	1	1	2	3	1	3	3	1	5
Beldi Giant	2777	1	2	5	1	2	3	1	1	1	1	5	1	2	2		1	2	3	5	2	1	1	2	1	3	2	2	4	4
Belford	7060	1	3	5	2	3	3	1	4					1	...	3	1	2	3	5	3	1	1	2	1	3	2	1	3	3
Blackhull	878	...	1	5	2	2	3	1	4	1	1	5	1	2	2	...	1	1	3	5	2	1	3	2	1	3	2	...	4	5
Blue	1247	1	2	5	1	3	3	1	4	1	1	5	1	1	2	...	1	3	3	5	2	1	2	2	1	3	2	2	5	4
Brandon 216	...	1	3	3	2	2	3	9	1	2	2	1	2	4	4	...	3	1	1	2	2	1	7	4	3	3	2	4	1	1
Byng	6089	5	1	5	2	2	3	9	1	1	2	3	1	3	3	...	3	1	1	2	2	1	2	4	3	3	1	6	1	3
California Coast	6115	1	2	5	2	3	3	1	4	1	1	5	1	1	1	...	1	3	3	5	2	1	1	2	1	3	2	1	2	4
California Mariout	1455	1	3	5	2	2	5	9	4	1	1	5	1	1	2	...	1	3	3	5	2	1	1	1	3	3	2	2	5	5
Canadian Thorpe	740	...	2	5	1	3	3	8	4	1	1	5	1	3	3	...	1	1	2	3	2	3	6	4	3	3	2	3	1	5
Charlottetown 80	2732	...	1	5	2	1	3	1	4	1	2	5	4	3	3	...	1	1	2	3	2	1	6	4	1	3	2	1	1	3
Chevron	1111	5	1	5	2	2	3	1	1	1	1	5	1	3	3	...	1	1	1	4	2	1	4	2	1	3	2	3	1	2
C. I. 7008	7008	1	3	5	1	3	3	1	4	1	1	5	1	2	2	...	1	3	3	5	2	1	1	2	1	3	2	1	3	5
Club Mariout	261	3	3	5	1	3	3	1	4	1	1	5	1	2	2	...	1	3	3	5	2	3	1	2	1	3	2	3	1	5
Coast	690	2	2	5	2	3	3	1	4	1	1	5	1	1	1	...	1	3	3	5	2	1	1	2	1	3	2	1	4	4
Colsess	2792	2	2	5	1	3	3	1	4	...	...	...	...	2	...	2	1	2	1	4	2	1	1	2	1	3	2	3	3	2
Common Six-Row	4625	1	2	5	2	3	3	1	4	1	1	5	1	2	2	...	1	3	3	5	2	1	1	3	1	2	2	2	2	4
Common Six-Row (4307 M. C.)	...	3	1	5	2	2	3	1	1	1	1	5	2	2	2	...	1	1	1	3	2	1	5	4	1	3	2	1	3	2
Compana	5438	...	3	5	2	1	3	9	4	1	1	4	1	2	2	...	2	1	3	4	2	1	8	4	3	1	3	1	1	5
Composite Cross selection (36Ab. 109)	7155	1	3	5	1	3	3	1	4	1	1	5	1	3	3	...	1	2	3	5	2	1	5	2	1	3	2	1	5	4
Composite Cross selection	5449	1	3	5	1	3	3	1	4				...	2	...	2	1	3	3	4	2	1	1	2	1	3	2	4	3	3
Conway	6095	3	3	5	1	3	3	8	4	1	1	3	1	3	3	...	2	3	3	4	2	1	1	2	3	1	2	2	1	4
Dorsett	4821	2	1	5	1	3	3	9	1	1	1	5	2	2	2	...	1	2	2	2	2	1	3	3	3	3	2	...	4	3
Duplex		3	2	5	2	2	3	9	1	1	1	5	1	2	2	...	1	3	3	3	2	1	5	4	3	2	3	1	1	3
Ezond	6265	5	3	2	4	2	3	3	4	1	2	1	1	3	3	...	3	2	3	4	2	1	5	2	1	3	2	3	3	4
Ezond selection (Wyo. 111-38-17)	...	2	1	4	2	3	3	9	1	1	2	3	1	3	3	...	3	2	3	5	2	1	1	2	3	3	2	2	4	5
Flynn	1311	3	2	5	1	3	3	9	4	1	1	4	1	2	2	...	2	3	3	5	2	1	1	2	3	1	2	4	1	5
Flynn 1	5911	3	2	2	1	3	3	12	4	1	1	3	1	3	3	...	1	3	3	5	2	1	7	2	3	1	3	6	1	4
Flynn 37	5918	3	1	2	1	3	3	11	4	1	1	1	1	3	3	...	2	3	3	4	2	1	7	2	3	1	3	4	1	4
Flynn selection	...	3	1	2	1	3	3	12	4	1	1	2	1	3	3	...	1	3	3	4	2	1	5	2	3	3	3	5	1	4
Flynn × Vaughn	...	3	1	2	1	3	3	12	4	1	1	2	1	3	3	...	1	3	3	4	2	1	5	2	3	3	3	5	1	4
Franklin Malt	5915	4	1	5	2	3	3	1	3	1	1	5	1	3	2	...	1	2	2	4	3	1	1	2	1	3	2	1	2	3
Galore	7150	4	1	2	4	1	3	11	4	2	2	1	1	3	3	...	3	1	1	3	2	1	7	3	3	3	2	6	1	3
Gartons	7016	5	1	5	2	2	3	1	1	1	1	5	2	2	2	...	1	1	1	3	2	1	5	4	1	3	2	2	2	2
Glabron	4577	5	1	1	3	1	3	12	1	2	2	1	2	3	3	...	3	1	1	3	2	1	5	2	3	3	2	4	2	2
Glacier	6976	3	3	5	1	2	3	9	2	1	1	4	1	2	2	...	1	3	3	5	2	1	1	2	3	1	3	2	1	5
Goldfoil	928	...	1	5	2	1	3	9	4	1	1	3	2	3	3	...	3	1	1	3	2	1	8	4	3	3	2	3	1	3
Hannchen	531	...	1	5	3	1	3	8	4	1	2	5	3	3	3	...	1	1	2	4	1	1	8	5	3	3	2	4	1	3
Hero	4602	1	3	2	1	3	3	12	4	1	1	1	1	4	4	...	2	3	3	5	2	2	5	2	3	3	2	6	1	4
Horn	926	...	1	5	2	1	3	1	4	1	2	5	1	3	3	...	1	1	2	3	2	1	9	4	1	3	2	3	1	4
Horsford	1775	1	3	5	2	2	3	1	4	...	...	...	...	2	...	3	1	1	3	5	3	1	1	4	1	3	2	1	4	3
Hybrid Composite (Nebr. 3S1162)	7114	4	3	3	3	2	2	12	1	3	3	1	1	3	3	...	3	1	3	3	2	1	7	2	3	3	2	3	4	2
Hybrid Composite (Nebr. 3S1175)		3	3	2	1	3	4	11	4	1	1	1	1	3	3	...	3	3	3	4	2	1	7	2	3	3	3	5	3	4
Lico	6279	3	3	2	2	2	3	2	4	1	1	1	1	3	3	...	2	2	3	4	2	1	7	2	1	1	2	4	1	4
Lion	923	3	3	2	2	2	3	9	4	1	1	1	1	3	3		3	2	2	3	2	1	7	4	3	3	2	...	3	4
Manchuria	2330	3	1	5	3	2	3	1	1	1	1	5	1	3	3		3	1	1	3	3	1	1	2	1	3	2	1	2	2
Manchuria	2947	3	1	5	3	2	3	1	1	1	1	5	1	3	3		3	1	1	3	2	1	1	2	1	3	2	1	4	2
Manchuria	7151	3	1	5	3	2	3	1	1	1	1	5	1	3	3	...	3	1	1	4	2	1	1	2	1	3	2	1	1	3
Mars	7015	5	2	2	3	2	3	12	1	2	2	1	2	3	3		3	1	1	1	2	1	7	4	3	3	2	5	1	1
M. C. 8129	...	5	1	3	2	2	3	2	1	1	2	1	1	3	3		3	1	1	3	2	1	5	2	1	3	2	1	1	2
Meloy	1176	1	3	5	1	3	3	1	4	...	...		...	2	...	2	1	2	2	3	2	1	3	2	1	3	2	3	4	3
Meloy 3	4656	1	3	5	2	2	3	1	4				...	2		3	1	1	3	5	2	1	1	4	1	3	2	1	4	3
Mensury	4696	3	1	5	3	2	3	1	1	1	1	5	1	3	3	...	1	1	1	3	2	1	1	2	1	3	2	1	4	2

TABLE 68.—*Distribution of spring barley data by character groups in tables 32 to 66*—Continued

Varieties	C. I. No.	Table																												
		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	51	57	58	59	60	61	62	63	64	65	66
Mensury 32 (M. C.)		3	1	5	3	2	3	1	1	1	1	5	1	4	3		1	1	1	3	2	1	1	3	1	3	2	1	2	2
Mensury (Ott. 60)		3	1	5	2	2	3	1	1	1	1	5	1	3	3		1	1	1	2	2	1	1	2	1	3	2	1	2	2
Michigan Two-Rowed	2782		1	5	2	1	3	8	4	1	2	5	2	4	4		1	1	2	3	1	1	8	4	3	3	2	4	1	2
Minia	3556	1	3	5	1	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	1	3	2	1	1	2
Minn. 11-31-19		6	2	4	2	1	3	11	1	2	2	1	4	3	3		3	1	1	2	2	1	5	4	3	3	2	5	1	2
Montcalm	7149	4	1	3	2	2	3	9	1	1	1	1	1	3	3		3	1	1	3	2	2	5	4	3	3	2	3	1	3
Munsing	6009		1	5	3	1	3	10	4	2	1	4	1	3	3		2	1	3	4	2	1	3	2	3	3	2	3	1	3
Newal	6088	5	1	2	2	2	3	10	1	1	1	1	2	3	2		3	1	1	3	2	1	5	2	3	3	2	2	1	3
Nobarb	6335	4	1	2	3	1	3	2	2	2	2	1	2	3	3		3	1	1	4	2	1	7	2	1	3	2	1	1	3
O. A. C. 21	1470	3	1	5	3	2	3	1	1	1	1	5	1	4	4		1	1	1	3	2	1	1	2	1	3	2	1	1	2
O. A. C. 35-2-0		3	1	3	2	3	3	10	4	1	1	1	1	3	3		3	1	1	3	2	1	7	4	1	3	2	2	4	2
Oderbrucker	4666	5	1	5	2	2	3	1	1	1	1	5	2	3	3		1	1	1	3	2	1	1	4	1	3	2	2	4	2
Odessa	182	4	1	5	2	2	3	1	1	1	1	5	1	3	3		1	1	1	3	2	1	4	4	1	3	2	2	2	2
Olli	6251	3	1	5	2	3	3	1	1	1	1	5	4	3	3		1	1	1	3	2	1	5	4	1	3	2	2	2	2
O. P. R. 1		5	1	4	3	1	3	5	1	2	1	2	1	3	3		2	3	1	2	2	1	1	2	2	3	2	2	2	2
Peatland	5267	6	1	5	2	2	3	1	1	1	1	5	3	3	3		1	1	1	3	2	2	1	4	2	3	2	5	4	1
Peatland × Vaughn (S. Dak. 384)		5	2	5	2	2	3	8	4	1	1	4	1	2	2		1	3	3	5	2	1	1	2	2	3	2	2	1	1
Peatland × Vaughn (S. Dak. 317)		4	2	5	1	2	3	8	1	1	1	3	1	2	2		1	3	3	5	2	1	1	2	2	3	2	2	1	1
Perth	6025	1	3	5	1	3	3	8	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	2	3	2	2	1	3
Peruvian 19	6568	1	2	5	2	2	3	1	4	1	1	5	1	2	2		1	3	2	5	2	1	1	2	1	3	2	5	2	3
Plush	6093	4	1	3	3	2	3	10	4	1	2	1	1	3	3		3	1	1	2	2	1	7	4	2	3	2	2	2	3
Pontiac	4849	5	1	5	3	1	3	5	1	1	1	5	1	3	3		1	1	1	3	2	1	1	2	2	3	2	2	1	3
Prospect	6339	4	1	2	3	2	3	11	3	1	1	2	2	3	3		3	2	1	2	2	1	10	2	2	3	2	6	2	3
Queens	7021		1	5	2	3	3	8	4	1	2	3	1	3	3		1	3	2	4	2	1	1	2	2	3	2	6	3	1
Regal	5030	5	1	2	3	2	3	12	1	2	2	2	1	3	3		3	1	1	2	2	1	7	2	2	3	2	2	1	3
Rex	6618		1	2	2	1	3	11	2	1	2	2	2	4	4		3	1	2	3	2	1	9	3	2	3	2	5	1	2
Rojo	5401	3	2	5	2	1	3	3	11	4	1	1	2	1	4	4	2	3	3	4	2	1	7	3	2	3	2	7	2	2
Rufflyn	6374	1	2	5	2	3	3	1	4	1	1	5	1	3	2		1	3	3	5	2	1	1	2	1	3	2	1	1	2
Sanalta	6087		2	5	1	3	3	9	4	1	2	2	1	3	3		3	1	2	3	2	3	9	4	2	3	2	2	1	2
Scarab	995	1	3	5	1	3	3	9	1	1	1	5	1	1	2		3	2	3	3	2	3	5	4	2	3	2	3	1	1
Short Comfort	5907	5	3	5	3	2	3	9	1	2	2	2	1	3	2		2	2	1	3	2	1	4	2	2	3	2	4	1	2
Sixty Day	5031	1	1	5	2	2	3	1	4					3		2	1	1	1	3	2	1	1	2	1	3	2	5	1	2
Spartan	5027		1	2	2	1	3	12	4	1	1	1	1	3	3		3	1	2	3	2	1	9	2	2	3	2	2	1	2
Stavropol	5013	1	2	5	1	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	1	3	2	2	1	2
Steigum	907		1	5	3	1	3	8	4	1	2	5	2	4	3		1	1	2	3	2	1	8	4	2	3	2	6	1	2
Stephan			1	5	2	1	3	8	4	1	2	5	1	3	3		1	1	1	3	2	1	8	5	2	3	2	6	2	2
Tall Comfort	4578	6	1	4	5	1	3	9	1	2	2	1	1	4	4		3	2	1	2	2	1	7	3	2	3	2	1	1	1
Titan	7055	5	1	2	3	1	3	12	1	1	1	1	1	3	3		3	1	2	3	2	1	7	3	2	3	2	5	1	2
Trebi	936	2	1	5	2	3	3	1	1	1	1	5	1	3	2		1	2	3	5	2	2	2	4	2	3	2	1	1	1
Trebi × Regal	6358	4	1	3	4	2	3	1	1	1	2	2	2	3	3		3	1	1	4	2	1	1	2	1	3	2	1	1	1
Tregal	6359	5	1	4	4	2	3	1	1	1	1	5	1	3	3		3	1	2	3	2	1	10	2	1	3	2	5	1	1
Tunis	1383	1	3	5	1	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	1	3	2	1	1	3
Union Beardless	5976	1	3	5	1	3	3	1	4					3	3	2	1	3	3	4	2	2	1	4	1	3	2	5	1	3
Vance	4585		3	5	2	1	3	10	4	2	2	4	1	3	3		2	1	3	4	2	1	7	4	1	3	2	3	1	3
Vaughn	1367	3	2	5	1	3	3	9	2	1	1	4	1	3	2		1	3	3	5	2	1	1	2	1	3	2	4	1	2
Velvet	4252	6	1	2	2	1	3	11	1	2	1	1	1	3	3		3	1	1	2	2	1	5	4	3	3	3	6	1	2

Velvet × Trebi (Iowa sel. 15)	7118	5	2	3	3	1	3	2	1	2	2	1	1	2	2		3	2	1	4	2	1	5	2	1	3	2	1	1	4
Velvon	6109	3	3	2	3	2	3	4	3	1	1	1	1	3	3		3	3	3	4	2	1	7	4	1	3	2	2	1	4
Velvon 7		3	3	2	3	2	3	12	1	2	1	1	1	3	3		3	3	2	4	2	1	7	2	1	3	2	3	1	4
Velvon 11	7088	3	3	2	3	2	3	4	3	1	1	1	1	3	3		3	3	2	4	2	1	7	4	1	3	2	5	1	4
Warrior	6991	1	3	5	1	3	3	1	1					3		1	1	2	1	4	2	1	4	2	1	3	2	2	3	2
White Smyrna	910		3	5	2	1	3	9	4	1	1	4	1	2	2		1	1	3	5	2	1	8	2	3	2	3	1	1	5
Winter Tennessee	4633	1	1	5	2	3	3	1	4	1	1	5	1	2	2		1	3	3	5	2	1	1	2	1	3	2	2	4	4
Wisconsin Barbless	5105	7	1	1	5	1	3	13	4	2	2	1	1	4	4		3	1	1	2	2	2	7	2	3	3	2	5	1	2
Wisconsin 9	1275	4	1	5	2	3	3	1	1	1	2	5	1	3	3		1	1	1	3	2	1	1	2	1	3	2	2	1	2
Wisconsin H35-7-2-1-3	7115	5	1	2	3	2	3	10	1	1	2	1	4	2	2		3	1	1	4	2	1	7	4	3	3	2	2	1	2
Wisconsin H35-7-6-4-1	7116	5	1	2	3	1	3	10	1	1	2	1	2	2	2		3	1	1	3	2	2	7	4	3	3	1	2	1	2
Wisconsin H41-4-4-4-1		5	1	5	2	2	3	1	1	1	2	5	2	4	3		1	1	1	3	2	1	1	2	1	3	2	2	1	2

TABLE 69.—*Distribution of winter barley data by character groups in tables 2 to 31*

Varieties	C. I. No.	Table																							
		2	3	4	5	6	7	8	9	12	13	14	15	17	19	20	21	22	23	25	26	28	29	30	31
Admire	6377	5	5	4	4	3	2	1	3	2	1	2	2	1	2	3	3	2	1	1	1	4	2	2	3
Awnless	5029	2	6	3	1	2	3	1	2	1	1	1	4	3	1	3	5	2	1	1	5	6	3	4	1
Brier	7157	5	7	4	4	2	2	1	3	2	1	2	1	1	3	3	2	2	1	2	1	4	3	2	3
Brugh 76	6477	4	5	5	4	4	2	3	1	1	1	2	2	1	5	2	1	2	1	2	5	4	3	2	3
Bulgarian	521	5	6	6	2	4	3	3	3	2	2	3	4	1	4	3	2	2	2	2	4	3	4	2	3
Cascade	7146	3	6	7	2	4	2	3	5	2	2	3	3	1	2	3	1	3	1	2	4	4	4	2	3
Clemson Awnless	7040	2	6	3	2	2	4	3	6	2	1	2	3	1	3	2	5	2	1	1	4	3	3	2	1
Clemson Hooded	7042	3	6	3	3	1	2	3	5	2	2	2	2	1	5	2	4	2	2	1	1	4	4	2	3
Davidson	6373	4	5	2	4	2	2	3	3	2	1	2	4	1	3	1	4	2	1	2	1	4	4	2	2
Esaw	4690	5	1	5	1	2	2	2	1	2	2	1	3	3	3	1	4	2	1	2	5	6	3	4	1
Fayette	245	4	6	6	2	4	3	3	4	3	3	3	2	1	4	4	1	3	2	2	4	4	3	2	3
Ferguson	6498	5	6	4	3	4	3	3	4	2	2	3	2	1	2	4	1	3	2	4	5	4	3	2	3
Finley	5901	5	6	7	3	4	3	3	4	2	2	3	2	1	2	4	1	3	2	3	5	4	3	2	3
Hooded 16	6574	4	4	4	2	2	2	3	4	1	2	1	1	1	4	4	4	2	1	1	4	4	3	2	3
Huga	6998	4	5	5	3	2	4	3	2	1	2	2	2	1	4	3	4	3	1	2	1	4	3	2	3
Iredell	6571	4	4	4	3	2	4	3	3	1	2	2	2	1	5	3	4	2	2	1	1	4	3	2	3
Jackson	6569	4	3	6	4	4	2	3	4	2	2	2	2	1	4	4	1	2	2	2	1	3	3	2	3
Jackson 1	7045	4	4	4	4	2	2	2	3	2	2	3	4	1	4	4	1	2	1	2	1	4	3	2	3
Kansas Southeast strain	7070	5	5	5	4	3	2	1	3	2	1	2	2	1	2	3	3	2	1	2	1	4	2	2	3
Kentucky 1	6050	5	5	5	4	4	2	3	3	1	1	2	2	1	2	3	1	2	1	2	4	4	2	2	3
Kentucky 2	6148	5	5	5	4	2	2	1	3	1	1	2	2	1	4	3	2	2	1	2	1	4	2	2	3
Kentucky 6	4678	5	5	4	4	2	2	1	4	2	2	2	1	1	3	2	3	2	1	2	1	4	3	2	3
Kentucky 11	6021	4	3	5	2	3	2	1	8	2	3	3	1	1	4	3	1	3	3	1	1	4	3	2	4
Kentucky 36	4677	5	5	4	3	3	2	1	4	2	1	2	2	1	2	2	1	2	1	2	1	4	3	2	3
Kirwin	7075	4	5	4	4	3	2	1	3	2	1	2	2	1	2	3	3	2	1	1	1	4	2	2	3
Marnobarb	6120	3	3	3	2	1	2	2	5	2	3	2	1	1	5	1	4	2	1	1	1	3	3	2	3
Marett Awnless 1	7073	2	6	3	2	2	4	3	6	2	1	2	3	1	5	3	5	2	1	1	5	3	3	2	1
Marett Hooded 4	7074	4	6	3	3	1	2	3	4	1	2	2	2	1	4	3	5	2	1	1	1	4	3	2	3

TABLE 69.—*Distribution of winter barley data by character groups in tables 2 to 31*—Continued

Varieties	C. I. No.	Table																								
		2	3	4	5	6	7	8	9	12	13	14	15	17	19	20	21	22	23	25	26	28	29	30	31
Mercer	7071	5	5	7	4	3	2	1	3	2	1	2	2	1	2	4	3	2	1	2	4	3	2	2	3
Michigan Winter	2036	5	5	5	4	2	2	1	3	2	2	3	1	1	3	3	3	2	1	2	1	4	3	2	3
Missouri Early Beardless	6051	4	3	3	3	1	3	3	4	2	2	2	2	1	4	2	4	2	1	1	4	4	3	2	4
Nakano Wase	754	1	1	1	1	1	3	2	6	2	1	2	4	3	2	1	5	2	1	1	5	5	3	1	4
Nassau	7022	4	3	4	3	2	2	1	6	2	3	3	2	1	4	3	3	3	2	2	4	4	3	2	3
New Mexico Winter 1	7065	5	6	7	2	4	2	3	4	2	2	3	3	1	2	4	2	3	2	2	4	4	3	2	3
North Carolina Hooded 26	7026	3	6	3	3	2	2	3	3	2	2	2	2	1	5	1	5	3	2	1	4	4	4	2	3
Ohio 1	7072	5	5	4	3	3	2	1	3	2	2	2	2	1	2	3	3	2	1	2	4	3	2	2	3
Olympia	6707	5	5	4	4	5	2	1	3	2	1	2	2	1	3	3	1	2	1	2	5	4	3	2	3
Oregon 34-4180A		5	5	4	3	3	2	1	4	2	1	2	2	1	3	2	1	2	1	2	1	3	4	2	3
Oregon 36-492		3	6	7	2	4	2	3	5	2	2	2	2	1	2	4	1	3	1	2	4	4	4	2	3
Oregon 36-513		2	6	3	2	3	2	3	4	2	2	2	2	1	2	4	1	2	1	3	1	4	4	2	3
Poland	6280	5	5	4	3	3	2	1	3	2	1	2	1	1	2	4	2	2	1	2	5	4	3	2	3
Polders	3213	5	5	4	3	5	2	1	3	2	1	2	3	1	3	2	1	2	1	2	1	4	3	2	3
Purdue 21	4581	5	5	6	4	4	2	1	3	2	1	2	2	1	4	3	2	2	1	2	1	4	3	2	3
Purdue 1101	4582	5	5	6	3	4	2	1	3	1	1	2	2	1	4	5	1	2	1	2	1	4	3	2	3
Purdue 28154 A3-1-1-6	7067	4	5	4	4	4	2	1	3	2	2	3	1	1	2	1	1	2	2	2	1	3	3	2	3
Purdue 28156 A3-2-2-2	6562	5	5	5	5	4	2	3	3	1	2	3	1	1	4	1	2	2	2	2	4	3	3	2	3
Randolph	6372	4	6	3	2	1	3	3	4	2	2	2	2	1	4	3	5	2	1	2	1	4	3	2	3
Reno	6561	5	5	5	4	2	2	2	3	2	1	2	2	1	3	3	3	2	1	2	1	4	3	2	3
Santiam	6367	5	5	5	3	4	2	1	3	2	1	2	2	1	3	4	1	2	1	2	1	4	3	2	3
Scottish Pearl	277	5	5	5	3	3	2	1	2	2	1	2	2	1	3	3	2	2	1	2	1	4	3	2	3
Smooth Awn 86	6268	4	3	3	2	2	2	1	5	2	2	2	2	1	4	3	5	2	1	1	5	4	3	2	3
Smooth Awn 88	7028	4	4	3	2	2	2	3	4	2	3	3	1	1	3	3	5	3	2	1	5	4	3	2	3
Sunrise	6272	2	1	3	1	1	2	1	6	2	1	2	3	1	3	1	5	2	1	1	5	4	3	2	3
Tenkow	646	5	6	6	2	4	2	3	4	2	2	3	2	1	2	3	2	3	2	3	5	4	3	2	3
Tennessee Beardless 5	3384	4	3	5	4	4	2	3	8	2	2	2	2	1	4	3	1	2	1	2	4	3	3	2	3
Tennessee Beardless 6	2746	4	4	5	2	2	2	3	4	1	2	2	2	1	4	3	4	2	1	2	4	4	3	2	3
Tennessee Winter	257	4	5	4	3	1	3	1	3	2	1	2	1	1	3	3	3	2	1	2	1	4	3	2	3
Tennessee Winter	6034	5	4	7	3	4	3	3	3	2	3	4	1	1	2	3	5	2	1	2	1	4	3	2	3
Tennessee Winter 52	3543	4	5	5	3	2	4	1	3	2	1	1	1	1	3	3	3	2	1	2	1	4	3	2	3
Tennessee 4B17-640	7076	5	5	6	4	4	2	3	2	2	2	2	3	1	4	2	2	2	1	2	1	4	3	2	3
Texan	6499	4	6	6	2	2	2	3	3	2	2	2	3	1	2	4	1	2	1	2	1	4	4	2	3
Tucker	7039	4	5	4	4	2	2	3	2	1	2	1	2	1	4	2	4	2	1	2	1	4	3	2	3
Ward	6007	5	5	4	4	3	2	1	3	1	1	2	2	1	3	3	3	2	1	2	1	4	4	2	3
Winter Club	592	5	7	7	3	5	2	3	3	2	1	2	4	3	3	1	1	2	1	2	4	5	4	2	3
Wintex	6127	5	6	7	2	4	2	3	3	2	2	3	2	1	2	3	3	2	1	2	2	4	3	2	3
Wisconsin Winter	2159	4	5	5	3	2	2	1	3	2	1	2	2	1	3	3	3	2	1	2	1	5	4	2	3
Wong	6758	2	2	2	3	4	2	1	7	2	1	1	2	1	3	1	1	2	1	1	5	4	3	2	3
Woodwin	7033	5	5	4	3	3	2	1	3	2	1	2	2	1	2	3	3	2	1	2	1	4	3	2	3
York Hooded	7038	4	3	5	4	2	2	3	4	1	2	2	2	1	4	2	4	2	1	2	4	3	3	2	3

TABLE 70.—*Distribution of winter barley data by character groups in tables 32 to 66*

Varieties	C. I. No.	Table																										
		32	33	34	35	36	37	38	39	40	41	42	44	45	46	47	48	54	57	58	59	60	61	62	63	64	65	66
Admire	6377	4	1	5	3	2	3	1	1	1	1	5	1	1	---	1	2	3	2	1	1	2	1	3	2	1	3	2
Awnless	5029	1	3	5	2	3	3	10	6	---	---	---	2	---	---	1	1	1	1	2	5	4	3	3	3	1	4	1
Brier	7157	4	1	5	3	2	3	1	1	1	2	5	2	2	---	1	1	3	2	1	1	4	1	3	2	1	3	2
Brugh 76	6477	1	2	5	2	2	3	3	1	1	---	---	3	2	2	1	1	3	2	1	1	2	1	3	2	2	1	5
Bulgarian	521	4	1	5	3	1	4	1	1	1	1	5	2	---	---	1	2	3	2	1	5	4	1	3	2	2	1	4
Cascade	7146	4	2	5	2	2	3	1	1	1	1	5	3	3	---	1	2	3	2	1	4	4	1	3	2	2	1	3
Clemson Awnless	7040	3	3	5	2	2	3	3	10	1	---	---	2	---	---	1	1	3	2	1	7	4	3	3	3	2	3	2
Clemson Hooded	7042	3	2	5	2	2	3	3	1	1	---	---	3	---	2	1	2	3	1	1	5	1	1	3	3	4	3	3
Davidson	6373	4	1	5	2	2	3	1	4	1	1	5	2	2	---	1	2	3	2	1	1	2	1	3	2	2	4	3
Esaw	4690	1	3	5	1	2	2	1	5	4	4	5	1	2	---	1	2	2	1	3	1	2	1	3	3	3	1	2
Fayette	245	3	1	5	3	2	3	1	1	1	1	5	3	3	---	1	2	5	2	3	2	4	2	1	3	2	6	5
Ferguson	6498	3	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	5	2	1	1	4	2	1	3	2	3	4
Finley	6901	3	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	5	2	1	1	4	2	1	3	2	3	4
Hooded 16	6574	3	1	5	2	2	3	1	1	---	---	---	2	---	3	1	1	4	2	1	4	4	1	3	2	2	1	2
Huga	6998	3	2	5	2	2	3	1	4	---	---	---	2	---	2	1	2	3	2	1	1	2	1	3	2	2	1	2
Iredell	6571	2	1	5	2	2	3	3	1	1	---	---	2	---	3	1	2	3	2	1	4	2	1	3	2	2	1	2
Jackson	6569	4	1	3	2	2	3	3	1	1	1	1	3	3	---	3	3	3	2	1	5	2	1	3	2	2	1	4
Jackson 1	7045	3	1	2	2	2	3	3	1	1	1	1	3	3	---	3	1	3	2	1	7	4	1	3	2	2	1	3
Kansas Southeast strain	7070	4	1	5	2	2	3	5	1	1	1	5	1	1	---	1	2	3	2	1	1	2	1	3	2	2	1	3
Kentucky 1	6050	4	1	5	2	2	3	1	1	1	2	5	1	1	---	1	2	3	2	1	1	2	1	3	2	2	1	3
Kentucky 2	6148	4	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	4	2	1	1	2	1	3	2	2	1	3
Kentucky 6	4678	4	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	3	2	1	1	2	1	3	2	2	1	3
Kentucky 11	6021	4	1	5	2	2	3	6	4	1	2	1	3	3	---	1	3	3	2	1	10	4	2	3	2	2	1	3
Kentucky 36	4677	4	1	5	3	3	3	1	1	1	1	5	2	2	---	1	2	4	2	1	1	2	1	3	2	2	1	3
Kirwin	7075	4	1	5	3	3	3	1	1	1	1	5	1	1	---	1	2	4	2	1	1	2	1	3	2	2	1	3
Marnoburb	6120	4	1	2	2	2	3	7	1	2	2	1	4	4	---	3	1	3	2	1	5	2	1	3	2	2	1	2
Marett Awnless 1	7073	3	3	5	2	2	3	10	4	---	---	---	2	---	---	1	1	3	2	2	5	4	3	3	2	3	2	3
Marett Hooded 4	7074	3	2	5	2	3	3	1	1	---	---	---	3	---	2	1	2	3	2	1	1	5	1	3	2	2	1	3
Mercer	7071	4	1	5	2	3	3	1	1	1	1	5	2	2	---	1	2	3	2	1	1	4	1	3	2	2	1	3
Michigan Winter	2036	4	1	5	2	3	3	1	1	1	1	5	3	2	---	1	1	3	2	1	1	2	1	3	2	2	1	3
Missouri Early Beardless	6051	1	1	5	2	3	3	1	1	---	---	---	2	---	3	1	1	2	2	2	1	4	3	3	2	2	1	2
Nakano Wase	754	1	3	5	2	2	3	1	10	4	6	6	5	2	---	1	1	2	2	2	1	4	1	3	2	2	1	2
Nassau	7022	3	1	2	2	2	3	3	4	3	1	2	3	3	---	3	3	3	2	2	1	5	4	1	3	2	5	5
New Mexico Winter 1	7065	4	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	5	2	2	1	1	4	1	3	2	1	2
North Carolina Hooded 26	7026	3	1	5	2	3	3	1	1	---	---	---	2	---	2	1	2	3	2	1	1	4	1	3	2	2	1	3
Ohio 1	7072	4	1	5	3	2	3	1	1	1	1	5	2	1	---	1	2	4	2	1	1	2	1	3	2	2	1	3
Olympia	6107	5	1	5	3	2	3	10	1	1	1	5	2	2	---	1	3	4	2	1	1	2	1	3	2	2	1	3
Oregon 34–4180A		4	1	5	3	3	3	10	1	1	1	5	2	2	---	1	2	4	2	1	1	2	1	3	2	2	1	3
Oregon 36–492		4	2	5	2	2	3	1	1	1	1	5	3	2	---	1	2	5	2	1	5	4	1	3	2	2	1	3
Oregon 36–513		4	1	5	3	2	3	1	1	1	1	5	2	2	---	1	2	5	2	1	1	2	1	3	2	2	1	3
Poland	6280	5	1	5	3	2	3	1	1	1	1	5	2	2	---	1	3	4	2	1	1	2	1	3	2	2	1	3
Polders	3213	4	1	5	4	2	3	9	1	1	1	5	2	2	---	1	2	4	2	1	1	2	3	3	2	2	4	2
Purdue 21	4581	4	1	5	2	3	3	1	1	1	2	5	2	2	---	1	3	4	2	1	1	2	2	3	2	2	3	2

TABLE 70.—*Distribution of winter barley data by character groups in tables 32 to 66*—Continued

Varieties	C. I. No.	Table																										
		32	33	34	35	36	37	38	39	40	41	42	44	45	46	47	48	54	57	58	59	60	61	62	63	64	65	66
Purdue 1101	4582	4	1	5	3	3	3	5	1	1	1	5	2	2	----	1	3	4	2	1	1	2	2	3	2	2	3	3
Purdue 28154 A3-1-1-6	7067	5	1	3	3	3	3	6	1	2	2	1	3	3	----	3	3	3	2	1	7	2	2	3	2	2	5	2
Purdue 28156 A3-2-2-2	6562	5	1	4	2	3	3	7	1	2	2	1	3	3	----	3	2	3	2	1	7	2	2	3	2	2	3	4
Randolph	6372	3	1	5	2	3	3	1	1	1	1	5	2	2	----	1	2	4	2	1	1	4	2	3	2	1	2	1
Reno	6561	4	1	5	3	2	3	5	1	1	1	5	2	2	----	1	2	3	2	1	1	2	2	3	2	1	1	3
Santiam	6367	4	1	5	3	3	3	5	1	1	1	5	2	2	----	1	3	4	2	1	1	2	2	3	2	1	2	3
Scottish Pearl	277	4	1	5	3	1	3	1	1	2	2	5	2	2	----	1	2	4	2	1	1	2	1	3	2	2	1	1
Smooth Awn 86	6265	5	1	2	2	2	3	7	4	2	2	1	2	2	----	3	3	3	2	1	5	2	3	2	2	2	5	1
Smooth Awn 88	7028	5	1	1	2	2	3	12	4	2	2	1	3	3	----	3	2	3	2	1	5	2	3	2	2	2	6	1
Sunrise	6272	1	3	5	2	2	1	10	4	6	6	5	2	2	----	1	1	2	2	3	1	2	3	2	3	2	4	1
Tenkow	646	3	1	5	3	2	3	1	1	1	1	5	2	2	----	1	3	5	2	1	1	2	3	3	2	2	5	3
Tennessee Beardless 5	3384	2	1	5	2	2	3	1	1	----	----	----	2	----	3	1	2	3	2	1	1	3	1	3	2	2	2	1
Tennessee Beardless 6	2746	3	1	5	2	3	3	1	1	----	----	----	2	----	2	1	2	3	2	1	1	4	1	3	2	2	2	1
Tennessee Winter	257	4	1	5	3	2	3	1	1	1	1	5	2	2	----	1	3	3	2	1	1	3	1	3	2	2	2	2
Tennessee Winter	6034	4	1	5	3	2	3	1	1	1	1	5	2	2	----	1	3	4	2	1	5	2	1	3	2	1	1	2
Tennessee Winter 52	3543	4	1	5	2	2	3	1	1	1	1	5	2	2	----	1	2	3	2	1	1	2	1	3	2	2	5	1
Tennessee 4B17-640	7076	3	2	5	3	2	3	1	1	----	----	----	2	----	3	1	1	3	1	1	1	1	1	3	2	2	6	1
Texan	6499	3	1	3	2	2	3	7	1	2	1	1	3	3	----	3	2	4	2	1	7	4	2	2	2	2	1	4
Tucker	7039	1	1	5	2	3	3	1	1	----	----	----	3	----	3	1	2	3	2	1	1	2	1	3	2	2	1	1
Ward	6007	4	1	5	2	2	3	1	1	1	1	5	2	2	----	1	2	3	2	1	1	2	1	3	2	2	1	3
Winter Club	592	1	3	5	2	3	3	9	1	2	1	5	2	2	----	1	2	5	2	1	1	2	1	3	2	2	2	1
Wintex	6127	3	1	5	3	2	3	1	1	1	1	5	2	2	----	1	3	5	2	1	4	2	1	3	2	2	2	2
Wisconsin Winter	2159	4	1	5	3	2	3	1	1	1	1	5	2	2	----	1	2	3	2	1	1	2	1	3	2	2	5	3
Wong	6728	1	3	5	2	3	3	9	1	5	5	5	1	1	----	1	1	4	2	1	1	2	1	3	2	2	1	1
Woodwin	7033	4	1	5	3	2	3	1	1	1	1	5	1	1	----	1	2	3	2	1	1	2	1	3	2	2	3	2
York Hooded	7038	3	1	5	2	3	3	1	1	----	----	----	3	----	2	1	2	3	2	1	1	2	1	2	2	2	2	2

TABLE 71.—*Summary showing the taxonomic value of the barley characters and the environmental influence on the expression of these characters*

Character studied	Taxonomic value				Influence of environment on character		
	Very good	Good	Minor	None	None	Moderate	Great
Growth characters:							
Spring or winter growth habit		X				X	
Early growth			X				X
Time of heading			X				X
Postharvest seed dormancy			X				
Leaf characters:							
Hairiness of leaf sheaths		X			X		
Color of leaves				X			X
Length and width of leaves			X				X
Anthocyanin in leaf sheaths and auricles			X				X
Waxiness of leaf sheaths and leaves			X				X
Position of leaves before heading date			X				X
Size and shape of flagleaves			X				X
Curling of flagleaves			X				X
Size and shape of auricle and ligules				X			
Roughness of leaves				X			
Number of stem leaves				X			
Stem characters:							
Height of plants			X				X
Strength of straw			X				X
Number of exposed nodes				X			X
Anthocyanin in nodes			X				X
Anthocyanin in stems			X				X
Shape of neck			X			X	
Distance from flagleaf to spike			X			X	
Shape of collar		X				X	
Hairiness of nodes				X			
Spike characters:							
Number of rows in spike	X				X		
Shape of spike			X			X	
Length of spike			X				X
Waxiness of spike			X				X
Spike density		X				X	
Tweaked spike			X			X	
Number of sterile spikelets at base of spike			X				X
Overlapping of lateral kernels			X			X	
Position of spike						X	
Toughness of rachis			X			X	
Brittleness of rachis	X				X		
Hairiness of rachis edges		X			X		
Length of basal rachis internode			X			X	
Shape of rachis internode			X			X	
Glume length			X		X		
Hairiness of glumes		X			X		
Length of glume awns	X				X		
Barbing of glume awns		X				X	
Length of awns	X				X		
Barbing of awns		X				X	
Deciduous awns			X			X	
Anthocyanin in glume awns and awns			X				X
Hood contrasted with awns	X				X		
Elevation of hoods			X			X	
Hood appendages on middle lobe			X			X	
Length of stamens			X			X	
Hairiness of stigma		X			X		
Threshability			X				X
Shattering			X				X
Rachillate lateral kernels				X			
Shape of rachis or rachis internodes				X			
Distance between glumes at point of attachment				X			
Glume width				X			
Width of awn at tip of lemma				X			
Deciduous lemma				X			
Size of middle lobe of hood				X			

TABLE 71.—*Summary showing the taxonomic value of the barley characters and the environmental influence on the expression of these characters*—Continued

Character studied	Taxonomic value				Influence of environment on character		
	Very good	Good	Minor	None	None	Moderate	Great
Kernel characters:							
Naked contrasted with covered kernels	x				x		
Kernel length		x				x	
Germ length			x			x	
Shape of kernels		x				x	
Lemma-base shape			x			x	
Lemma teeth		x				x	
Lemma hairs		x			x		
Wrinkling of hulls			x				x
Rachilla hairs	x				x		
Rachilla abortion		x				x	
Length of rachilla			x			x	
Color of lemma and palea			x				x
Color of caryopsis		x				x	
Color of aleurone (humid climate)		x				x	
Color of aleurone (dry climate)	x				x		
Width and depth of ventral crease				x			x
Kernel weight			x				x
Width of point of attachment of kernels				x			

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