Climate and dormancy data reduce need for many regional alfalfa trials

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Efficiency in variety testing depends on choosing suitable locations for trials, and then on allocating to each location the varieties most likely to succeed in the area represented. These considerations are particularly important in California, where much alfalfa is grown in isolated areas and small mountain valleys. Before we began our research, the climatic similarities among these areas had not been studied. As a result, a great amount of testing has been conducted in climatically similar areas, a duplication of effort that is inefficient in time and labor and in providing information to growers.

In 1969, the Western Alfalfa Improvement Conferences established a committee on ecological zones to: (1) determine whether isolated production areas and small mountain valleys could be linked based on their climatic similarities, (2) develop a system of regional variety trials that would minimize the amount of testing required to determine areas of cultivar adaptation, and (3) develop a system whereby the data collected from these trials could be shared among both public and private agencies.

In a series of studies, we used cluster analysis to identify areas of similar climate, fall dormancy trials to describe varieties, and data from previous variety trials combined with results of the dormancy studies to develop a method of allocating varieties and experimental germplasm to regional variety trials.

Cluster analysis

Climatic and geographic data (number of frost-free days, mean temperature, annual precipitation, latitude, and elevation) were collected from 243 locations in the western United States, including 30 in California (J. H. Elgin *et al.*, 1982, *Alfalfa Growing Areas in the Western United States—Their Climates and Similarities*, Agricultural Research Service, U.S. Department of Agriculture, Technical Bulletin No. 1651, pp. 1-68). The climatic data were based on 30-year averages.

Subjecting these data to a cluster analysis made it possible to group together the locations most similar in environment (see map). Each dot on the map represents a location where we collected climatic data, and those of the same color are locations similar in climate, according to our analysis. Superimposing this map on a topographic map of California permitted us to identify continuous geographic regions with similar environments based on geographic features. This process produced eight climatically distinct regions in California: three regions in the "intermountain area" of northern California; the North Coast; the Owens Valley; the Central Valley, the Central and South Coast, and the area between the high and low deserts; the high deserts; and the southern low deserts and southern San Joaquin Valley (see map).

Variety trials are now being conducted at several locations within each of the clusters we have identified. University of California scientists are evaluating varieties for forage yields at 14 locations, and other researchers are conducting trials at numerous additional sites.

One way to reduce this number of testing locations is to compare environments. We began by describing the environment of each region (table 1). The southern low desert region (green area), for example, is characterized by 301 frost-free days, a mean temperature of 71°F, 5 inches of annual precipitation, 33° 27′ north latitude, and elevation of 557 feet. We then examined each location within the region to find one with an environment most similar to that description. We found that El Centro typically has 297 frost-free days, a mean temperature of 72°F, and annual precipitation of 2.3 inches, and it is located at north 32° 46′ and has an elevation of 50 feet below sea level.

In this way, we identified eight locations for regional variety testing: Tulelake, Cedarville, Yreka, Bishop, Palmdale, Davis, and Five Points, in addition to El Centro (table 2) These sites distributed throughout California (stars on map) fairly well represent the areas where varieties should be tested. The greater number of testing sites in the northeastern (intermountain) part of the state illustrates the variety of environments in the mountain valleys.

Coverage of the state might be improved by adding testing locations in the Central and South Coast, possibly at Salinas, and another on the North Coast, near Eureka. This would still be considerably fewer than the 14 locations now being used for variety tests. However, the alfalfa acreage in these two regions and economic considerations led to the decision that adding such locations would not be a wise investment of time; information can be obtained from similar areas or neighboring states.

Fall dormancy

Fall dormancy is the most important factor determining area of alfalfa adaptation, but information on this characteristic had previously been reported only in Minnesota. We began a study to determine how fall dormancy ratings in California compared with those in Minnesota, and to characterize California production areas. Seventeen varieties (table 3) were planted at several California locations, including Cedarville, Redding, Davis, Salinas, Five Points, Bakersfield, and El Centro.

Fall dormancy is thought to be conditioned by a combination of temperature and photoperiod. To measure the variation due to environment, we conducted trials in which plants were cut back on August 15, September 7, October 3, and October 23, and regrowth data were collected about three weeks after each cutting. This provided a gradient in both temperature and photoperiod.

The scoring system for fall dormancy data was based on a scale of 1 to 18, with 1 indicating maximum dormancy (table 3). Each increment in our scale represents 5 cm in natural plant height, a measurement of growth that takes into account stem length and stem angle.

Cultivars tended to rank in a similar

Analysis of climatic and geographic data identified eight distinct alfalfa-growing regions

TABLE 1. Climatic means and geographic data for the eight regions in California

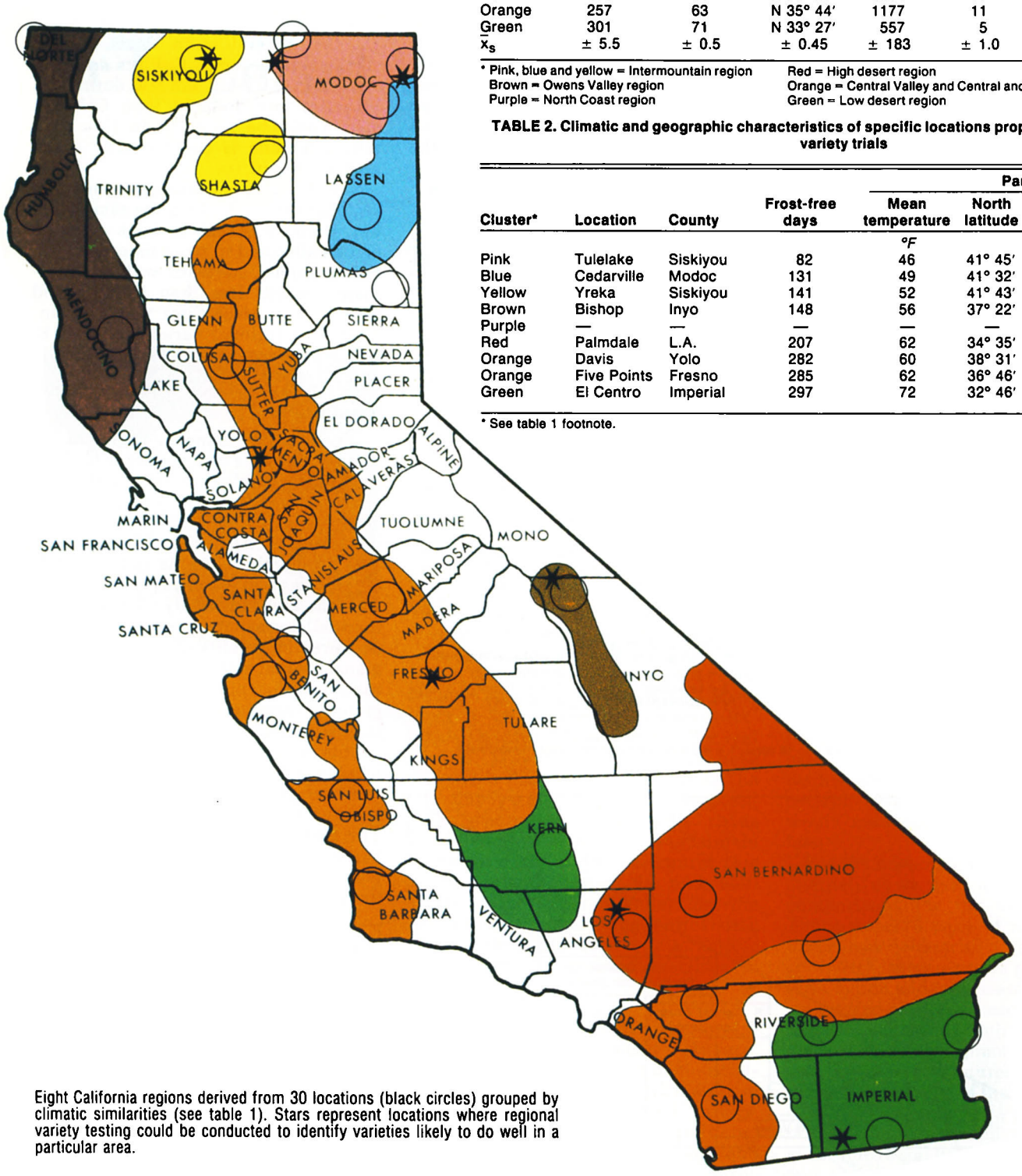
Cluster*	Frost-free days	Mean temperature	Latitude	Elevation	Annual precipitation
		°F		ft	in
Pink	108	45	N 42° 17′	5175	13
Blue	129	48	N 41° 45′	4313	12
Yellow	145	50	N 41° 04′	3839	10
Brown	151	52	N 37° 52′	4253	10
Purple	201	53	N 44° 02′	387	45
Red	205	61	N 33° 51′	3614	11
Orange	257	63	N 35° 44′	1177	11
Green	301	71	N 33° 27′	557	5
$\bar{x}_s$	± 5.5	± 0.5	± 0.45	± 183	± 1.0

* Pink, blue and yellow = Intermountain region
Brown = Owens Valley region
Purple = North Coast region
Red = High desert region
Orange = Central Valley and Central and South Coast region
Green = Low desert region

TABLE 2. Climatic and geographic characteristics of specific locations proposed for regional alfalfa variety trials

				Parameter			
Cluster*	Location	County	Frost-free days	Mean temperature	North latitude	Elevation	Annual precipitation
				°F		ft	in
Pink	Tulelake	Siskiyou	82	46	41° 45′	4035	10.9
Blue	Cedarville	Modoc	131	49	41° 32′	4670	14.2
Yellow	Yreka	Siskiyou	141	52	41° 43′	2625	18.8
Brown	Bishop	Inyo	148	56	37° 22′	4108	5.7
Purple	—	—	—	—	—	—	—
Red	Palmdale	L.A.	207	62	34° 35′	2596	7.9
Orange	Davis	Yolo	282	60	38° 31′	52	17.2
Orange	Five Points	Fresno	285	62	36° 46′	328	10.2
Green	El Centro	Imperial	297	72	32° 46′	−30	2.3

* See table 1 footnote.



Eight California regions derived from 30 locations (black circles) grouped by climatic similarities (see table 1). Stars represent locations where regional variety testing could be conducted to identify varieties likely to do well in a particular area.

manner, regardless of either date or location. However, the relative rank of cultivars with similar dormancy varied with both location and date.

Our analysis showed that fall dormancy scores for the same cultivars in Minnesota and at several of the California locations were similar, particularly after the October 3 cutting. Davis scores were most strongly correlated with those from most of the other California locations on the same dates as the strongest correlation with Minnesota data occurred — after the October 3 and 23 cuttings.

Thus, fall dormancy evaluations conducted at Davis can be used as a basis for the selection of varieties for alfalfa growers in a given region of California. Fall dormancy information allows us to separate one variety from another more precisely than does either the winter dormancy rating or the fall growth class (table 3). With the latter two ratings, varieties are placed only in broad groups.

Assignment of varieties

Based on the fall dormancy trials, we ranked a series of check varieties (see graph, triangles). We then identified varieties that were consistently high yielding, using data from variety trials conducted throughout California in the past. These successful varieties encompassed a broad range of fall dormancy scores, which were superimposed on the fall dormancy scores of the check varieties, providing an acceptable dormancy range that could be used in a given region.

For example, to allocate varieties to the low desert valley regional trial, we would include those which, based on fall dormancy scores taken after the October 23 cutting in Davis, ranked somewhere between DuPuits and Mesilla, and CUF-101 in fall dormancy. Varieties less dormant than CUF-101 also would be included in this trial, although none is commercially available at present.

Varieties will be allocated to the other regional variety trials in the same manner. Under this system, some cultivars can be allocated to more than one trial. For example, cultivars with fall dormancy scores less than DuPuits and greater than Mesa Sirsa would be included in regional variety trials at El Centro, Davis, and the West Side Field Station.

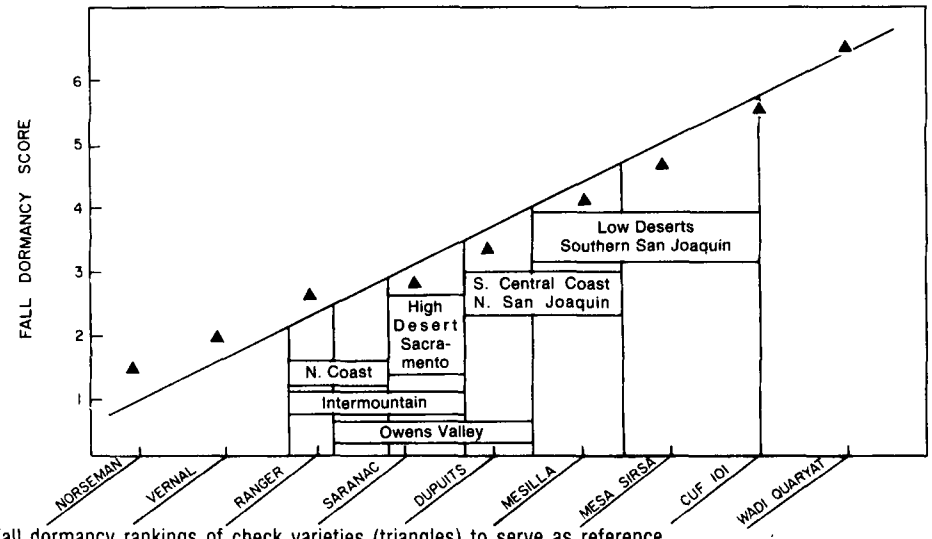
TABLE 3. Three types of ratings of the 17 alfalfa varieties evaluated at each of seven locations in California

Cultivar	Winter dormancy*	Fall growth†	Fall dormancy‡			
			8-15	9-07	10-03	10-23
	rating	*class*	*score*			
Norseman	VD§	1	4.3	4.1	1.1	1.0
Vernal	D	1	7.3	6.7	1.7	1.1
WL-202	D	1	7.9	6.7	2.0	1.2
Dawson	D	1	8.1	6.7	2.2	1.1
Warrior	D	1	8.2	7.5	2.6	1.4
Ranger	D	1	8.5	7.4	2.4	1.1
Saranac	D	2	8.7	7.7	2.7	1.3
Team	D	2	8.5	8.5	2.8	1.3
DuPuits	D	2	9.1	9.5	3.3	2.0
Lahontan	SD	3	9.4	7.8	2.2	1.4
Mesilla	MND	5	10.3	9.2	3.7	2.5
Joaquin 11	MND	5	10.7	10.5	4.4	3.5
African	VND	8	10.0	10.3	5.1	4.9
SW-44	ND	7	11.2	10.5	4.6	4.3
Mesa Sirsa	VND	7	10.9	10.8	4.9	4.5
CUF-101	VND	8	11.0	11.5	5.6	5.5
Wadi Quaryat	VND**	8	11.0	12.1	6.7	7.7

*Winter dormancy:
VND = very nonwinter dormant
ND = nonwinter dormant
MND = moderately nonwinter dormant
SD = semiwinter dormant
D = winter dormant
VD = very winter dormant

†Fall growth similarities:
1 = Vernal
2 = Thor
3 = Lahontan
4 = Caliverde 65
5 = DeKalb Brand 185
6 = Moapa 69
7 = UC Cargo
8 = CUF-101

‡ Fall dormancy on four dates at Davis scored on a 1 to 18 scale: 1 = most dormant and 18 = most nondormant.
§ Less fall growth than Vernal.
** More fall growth than CUF-101



Fall dormancy rankings of check varieties (triangles) to serve as reference points in allocating varieties to a given region.

Conclusion

Cluster analysis makes it possible to divide California into regions with similar climatic conditions and to choose an environmentally typical location within each region where variety trials could be conducted. Analysis of fall dormancy data from both California and Minnesota indicates that varieties can be allocated to the regional variety trials based on their fall dormancy scores. This strongly supports the validity of establishing regional trials at eight locations in California as an efficient means of identifying a group of varieties most likely to do well in a particular region.

This procedure does not consider differences in soil type and microclimate, however, so cultivars must be carefully selected within each dormancy group. The final choice of the best producing variety from within this group will depend on the grower's management practices.

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