Barley Variety Demonstration

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Elevation: 2800
Crop History:
Planted: Dec. 31, 1980
Seeding Rate: 180 lbs/A
Previous Crop: Cotton
Harvested: June 8, 1981
Irrigation: An estimated 24 acre inches per acre were applied to the plot. Rainfall supplied an additional amount.

Fertilizer:

Source	Lbs/Acre	Time of Application	Lbs N/acre	Lbs P_2O_5/acre
28-28-0	200	Prior to planting	46	46
NH_3	75	During first irrigation	62	0
NH_3	75	During second irrigation	62	0
		Total	170	46

Soil Analysis:

pH = 7.93 (paste with distilled H_2O);
$EC_e \times 10^3$ = 3.38 (to convert $EC_e \times 10^3$ to soluble salts, multiply $EC_e \times 10^3 \times 700$);
Soluble salts = 2366 ppm
N = 48.85 ppm (from CO_2 extraction. Nitrate reported as N. To convert N to NO_3, multiply N x 4.4);
P = 4.10 ppm (CO_2 extraction. Phosphate reported as P. To convert P to PO_4, multiply P by 3.1).
Date of Sample: Dec. 30, 1980 (University of Arizona Laboratory)
Plot Size: 400' x 12'

Entry	Yield (lbs/plot)1/ Rep 1	Rep 2	Rep 3	Rep 4	Ave. Yield (lbs)	Ht (in)	Bu Wt (lbs)	Lodging (%)	Yield2/ (lbs/A)
Gus	930	930	920	860	910	32	50	0	8270a
NK409	860	920	890	810	870	35	48	0	7900a
NK400	730	860	810	800	800	27	47	0	7230 b
NK401	680	800	760	750	750	31	47	0	6810 bc
Poco3/	610	800	810	710	730	22	49	0	6630 bc
Prato	670	760	640	710	690	35	48	10	6300 cd
Signal	520	670	710	650	640	40	50	100	5780 d

1/ At harvest, moisture content averaged 7%. All yields have been adjusted to a 10% moisture content.
2/ Yields followed by the same letter are not significantly different at the .05 level by the Student-Newman Keuls' Test.
3/ Poco barley could have been harvested 25 days earlier.

ENVIRONMENT INFLUENCES THE GROWTH AND YIELD OF TWO GENOTYPES OF SPRING BARLEY

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Summary

Field experiments were conducted from 1976 through 1978 at Yuma, Arizona and Logan, Utah to investigate the effects of environment on growth and grain yields of Arimar and Arizona 1970-1 barley (Hordeum vulgare L.) genotypes grown under irrigation. The genotypes were grown from December to June in Arizona and from April to August in Utah each year for three years.

Barley genotypes grown in Arizona required a longer period from planting to flowering and a shorter period from flowering to maturity; however, they produced taller plants, higher grain yields and higher straw yields than did the same genotypes grown in Utah.

In Arizona in each of the three years, Arimar required a longer period from planting to flowering and planting to maturity, required a shorter period from flowering to maturity, and produced taller plants than did Arizona 1970-1. The foregoing differences between genotypes did not exist in Utah. In general, differences in straw yields, grain to straw ratios, grain yields, and grain yield components between genotypes for the same location were not statistically different; however, the grain yields and straw yields from both genotypes were higher in Arizona than they were in Utah.

Optimum barley growth and grain yields are influenced by environment. The research reported in this paper demonstrated the fact that most commercially available barley genotypes have a relatively narrow environmental adaptation. New barley genotypes that have broad environmental adaptation should be developed in the future, so that they can be grown over a large geographical region.

Additional Index Words: Cultivars, Varieties, Plant Adaptation, Plant Breeding, Plant Culture.

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Introduction

Improved crop management practices and breeding techniques have resulted in high yielding commercial barley (*Hordeum vulgare* L.) cultivars. Cultivars grown under optimum environmental conditions and cultural practices usually attain their full yield potential. If a genotype is grown outside of its area of adaptation there may be a genotype-environment interaction that might lead one to underestimate its actual yield potential in its area of adaptation. A thorough knowledge of the relationships between genotypes and their environment can be used effectively by plant breeders in selecting barley cultivars with desirable agronomic qualities and wide adaptation.

Literature Review

The climate of a region determines cultivar adaptation and plant response through the normal growth stages from planting to maturity (Thorne et al., 1968). Willey and Holliday (1971) stated that yield potential of a crop depends on the environment and its interaction with the developing plant. Limitations by the environmental conditions of a given geographical region may prevent superior genotypes from expressing their full yielding potential (Stoskof et al., 1974). Thorne et al. (1968) reported that unfavorable environmental factors, at successive growth stages in wheat, had an additive effect in reducing grain yield.

Experiments under field situation and controlled conditions have indicated that barley responded to environmental factors such as temperature, light intensity, and photoperiod effects. Warrington et al. (1977) reported that wheat plants grown at low temperature during grain development had long culms, large flag leaves, and a high number of florets in each spikelet. Vegetative growth and grain development, however, were depressed when wheat plants were subjected to high day and night temperatures and low light intensities (Campbell and Read, 1968). According to Spiertz (1974), an increase in temperature within the range of 15 to 25C and a light intensity greater than 147 cal cm^{-2} day^{-1} accelerated the grain growth rate of wheat; however, post-floral development was shortened, resulting in low final grain yields. Darwinkel et al. (1977) reported that a short grain-filling period resulted in light seeds and low grain yields.

Tew and Rasmusson (1978) reported that the period from planting to flowering was longer when barley varieties were grown in short-day environments than when they were grown in long-day environments. Faris (1978) suggested that long photoperiods and high temperatures prior to heading resulted in short plants, small leaves, small heads and low floret fertility in barley. Faris and Guitard (1969) stated that barley plants grown in a short-day environment from planting to internode elongation produced a high number of florets per spikelet because short days extended floral development over a long period of time.

The purpose of the research presented in this paper was to investigate the effects of environment on the growth and grain yield of two barley genotypes grown under irrigation in the western United States.

Materials and Methods

An experiment was conducted from 1976 through 1978 in Yuma, Arizona and Logan, Utah to study the effects of environment on growth, forage yield, and grain yield of two barley genotypes ('Arimar' and 'Arizona 1970-1').

The Yuma, Arizona Experiment Station is located in southwestern Arizona at 32.5° N latitude and 114° W longitude. The Yuma valley has an elevation of 33 m above sea level. The annual precipitation for the valley is 8.6 cm and most of the rainfall is distributed throughout the barley growing season

(December - May). The mean temperature during the growing season ranges from 13C at planting to 24C at maturity and the solar radiation ranges from 269 langleys/day in December to 665 langleys/day in May. Yuma has its lowest sunshine (82%) in December and its highest sunshine in June (98%).

The Logan, Utah Experiment Station, located in northern Utah at 41.8° N latitude and 11.8° W longitude, has an elevation of 1,382 m above sea level. The total rainfall from April to August is 16 cm and about 85% comes during April and May. The minimum temperature ranges from 7C in April to 11C in August and the maximum temperature ranges from 16C to 29C in April and August, respectively. The normal frost-free growing season is 138 days; however, in 1978 the growing season consisted of 112 frost-free days.

The barley was planted in December and harvested in June in Arizona and it was planted in April and harvested in August in Utah. The seeding rate was 112 kg/ha and irrigation was applied as required at each location. Nitrogen fertilizer was applied before planting at rates of 56 kg/ha in Arizona and 168 kg/ha in Utah. The experimental design was a Split-Split Plot with four replications and the plot size was 0.37 m^2. Locations, years, and genotypes were assigned to main plots, sub-plots, and sub-subplots, respectively.

The data collected for each genotype at each location were: (1) days from planting to flowering, (2) days from planting to maturity, (3) days from flowering to maturity, (4) plant height, (5) heads per unit area, (6) seeds per head, (7) seed weight (8) grain yield, (9) grain volume-weight, (10) straw yield, and (11) grain/straw ratio.

All data were analyzed using the standard analysis of variance. Means were compared using the Student-Newman-Keuls' Test (SNK) as described by Little and Hills (1975).

Results and Discussion

Analysis of variance and SNK mean separation for average days from planting to flowering, flowering to maturity, planting to maturity, plant height, dry straw yield, and grain to straw ratio for Arimar and Arizona 1970-1 barley genotypes grown in Arizona and Utah are presented in Table 1.

Barley genotypes grown in Arizona required more time to flower and reach maturity than did the same genotypes grown in Utah. The period between flowering and maturity was shorter in Arizona than it was in Utah. Days from planting to flowering and planting to maturity, in both Arizona and Utah were fewer for Arizona 1970-1 than they were for Arimar; however, the period between flowering and maturity was shorter for Arimar than it was for Arizona 1970-1. The foregoing periods were not significantly different for genotypes in Utah; however, genotypes grown in Arizona showed clear differences indicating strong genotype-location interactions. The number of days required from planting to flowering, flowering to maturity, and planting to maturity for both genotypes were higher in 1977 than they were in 1976 and 1978 at both locations. Genotype comparisons for the same location and same year indicated that in Arizona, Arimar required more days from planting to flowering and planting to maturity and fewer days from flowering to maturity each year than did Arizona 1970-1. In Utah, the foregoing periods were not significantly different for the two genotypes.

In Arizona, barley genotypes grew 37% taller than they did in Utah. Arimar was significantly taller than Arizona 1970-1 in each location each year, except in Utah in 1976. Average straw yields from both genotypes were much lower in Utah than they were in Arizona. Arimar produced more straw than did Arizona 1970-1 in both Arizona and Utah; however, the differences in straw yields were not statistically significant, except in Arizona in 1977. Grain/straw ratios were higher in Utah than they were in Arizona. In Utah, the two genotypes did not differ in grain/straw ratio; however, in Arizona, Arimar had lower grain to straw ratios than did Arizona 1970-1 in 1977 and 1978.

Average number of heads per unit area, seeds per head, seed weight, grain yield per unit area, and grain-volume weight for Arimar and Arizona 1970-1 barley genotypes grown in Arizona and Utah are reported in Table 2. The number of heads per unit area were higher for Arizona 1970-1 than they were for Arimar. Differences between genotypes in number of heads were not due to location. The location by year interaction showed that the average number of heads per unit area for genotypes grown in Arizona declined from 1976 to 1978. In Utah, average number of heads for genotypes were similar in 1976 and 1977 but higher for Arizona 1970-1 than for Arimar in 1978. The average numbers of seeds/head for genotypes were higher in Arizona than they were in Utah. Average seeds/head for genotypes showed significant differences among years. In Arizona, seeds/head increased from 1976 to 1978. In Utah, there was an increase in seeds/head only in 1978. When genotypes were compared within the same year and location, Arimar produced more seeds/head than did Arizona 1970-1 in 1977 in Arizona and in 1978 in Utah; however, in 1978 in Arizona, Arizona 1970-1 produced more seeds per head than did Arimar. In general, seed weight followed the same pattern as number of seeds per head. Genotypes grown in Arizona produced heavier seeds than did genotypes in Utah. There were significant differences in seed weight among years and a significant location and year interaction. Arimar produced heavier seeds than did Arizona 1970-1 in Utah in 1978; however, there were no significant differences between genotypes at both locations during the other growing seasons. The average grain yields for both genotypes were higher in Arizona than they were in Utah; however, grain yields for the two genotypes were similar at a given location. Average grain yields from the two genotypes at both locations were higher in 1977 than they were in 1976 and 1978. Average grain volume-weights for the two genotypes were not statistically different between locations; however, significant differences were observed between years and for the interactions locations x years and genotypes x years.

Genotypes grown in Arizona required a longer period from planting to flowering than did the same genotypes grown in Utah. The day-length in Arizona between planting and flowering was shorter than it was in Utah. Thus, under short-day environments flowering may be delayed (Tew and Rasmusson, 1978). In Arizona, Arimar and Arizona 1970-1 produced taller plants, higher straw yields, and higher grain yields than they did in Utah. The reductions in growth and yields of the two genotypes in the longer day environmental conditions in Utah than in Arizona were similar to the observations made by Stoskof et al. (1974) in southern Canada. The higher number of seeds/head from genotypes grown in Arizona may be due to the more favorable short-day environment in Arizona than in Utah during floral development. Short-days in Arizona extended floral development over a longer period of time, resulting in a higher number of florets/spikelet in Arizona than those obtained in Utah (Faris and Guitard, 1969). In Utah, genotypes were subjected to longer photoperiods and higher temperatures prior to heading than were present in Arizona. The foregoing environmental conditions in Utah may have resulted in shorter plants, lower straw yields, and lower grain yields because of lower floret fertility in the environment in Utah than in the environment in Arizona. Similar observations were made by Faris (1978).

The data reported in this paper indicate that differences in environment between Logan, Utah and Yuma, Arizona during the seasons in which barley is grown are sufficient to produce widely different growth responses in the two barley genotypes. Since most commercially available barley genotypes have a relatively narrow environmental adaptation, future barley breeders should develop new genotypes that have a broad environmental adaptation, so that they will be productive over a large geographical region.

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TABLE 1

Average days from planting to flowering, flowering to maturity, planting to maturity, plant height, straw yield, and grain/straw ratio for two barley genotypes grown in Arizona and Utah for a three-year period (1976-78).

Location	Year	Genotype	Planting to flowering	Flowering to maturity	Planting to maturity	Plant height	Straw yield/m^2	Grain/ straw ratio
			(day)	(day)	(day)	(cm)	(g)	(ratio)
Arizona	1976	Arimar	100 a[+]	40 b	140 a	82 a	1034 a	0.82 a
		Arizona 1970-1	78 b	46 a	124 b	72 b	941 a	0.97 a
	1977	Arimar	102 a	42 b	148 a	90 a	1540 a	0.61 b
		Arizona 1970-1	81 b	58 a	139 b	67 b	836 b	1.05 a
	1978	Arimar	96 a	49 b	146 a	94 a	1233 a	0.44 b
		Arizona 1970-1	80 b	54 a	134 b	86 b	1154 a	0.62 a
Logan	1976	Arimar	48 a	68 a	116 a	53 a	463 a	0.90 a
		Arizona 1970-1	48 a	67 a	115 a	50 a	401 a	1.00 a
	1977	Arimar	56 a	50 a	106 a	59 a	544 a	0.99 a
		Arizona 1970-1	55 a	50 a	105 a	53 b	358 a	1.14 a
	1978	Arimar	51 a	55 a	106 a	75 a	412 a	1.11 a
		Arizona 1970-1	50 a	55 a	105 a	70 b	347 a	1.20 a
Sources of variation		df	-----------	-----------	-----------	Mean squares	-----------	-----------
Location (L)		1	17,442.2**	1,054.7**	10,413.5**	5,985.3**	5,914,638.0**	1.12**
Error (a)		6	0.4	0.4	0.6	3.3	7,833.7	0.01
Genotype (G)		1	1,312.5**	212.5**	623.5**	1,008.3**	471,240.3**	0.41**
L x G		1	1,017.5**	275.5**	315.2**	261.3**	106,032.0*	0.06ns
Error (b)		6	0.4	0.2	0.1	2.8	15,820.8	0.01
Year (Y)		2	106.2**	116.3**	6.3**	1,279.4**	50,725.7ns	0.05ns
L x Y		2	23.7**	682.9**	514.3**	70.4**	81,747.3ns	0.35**
G x Y		2	6.4**	49.0**	12.3**	89.4**	182,810.3*	0.04ns
L x G x Y		2	15.9**	27.0**	13.0**	63.1**	81,747.3ns	0.02ns
Error (c)		24	0.5	0.4	0.2	7.4	29,341.5	0.01

*, ** Significant at 5% and 1% levels, respectively; ns = not significant at 5%.
+ Means followed by the same letter, within years, for the same location, are not different at the 5% level of significance, using the Student-Newman-Keuls' Test.

TABLE 2

Average heads per unit area, seeds per head, seed weight, grain yield and grain volume-weight for two barley genotypes grown in Arizona and Utah for a three-year period (1976-1978).

Location	Year	Genotype	Heads/m^2	Seeds/head	1000-seed weight	Grain yield/m^2	Grain volume-weight
			(no.)	(no.)	(g)	(g)	(kg/hl)
Arizona	1976	Arimar	738 a	21 a	55.4 a	816 a	68 a
		Arizona 1970-1	790 a	21 a	53.5 a	894 a	68 a
	1977	Arimar	523 a	34 a	52.5 a	934 a	62 b
		Arizona 1970-1	601 a	28 b	52.3 a	872 a	65 a
	1978	Arimar	428 a	31 b	39.9 a	529 b	65 a
		Arizona 1970-1	442 a	41 a	38.5 a	679 a	65 a
Utah	1976	Arimar	580 a	16 a	44.8 a	395 a	68 a
		Arizona 1970-1	534 a	17 a	45.8 a	398 a	65 b
	1977	Arimar	634 a	17 a	50.4 a	538 a	66 a
		Arizona 1970-1	596 a	13 a	48.9 a	406 a	65 a
	1978	Arimar	432 b	23 a	45.1 a	452 a	64 a
		Arizona 1970-1	618 a	16 b	41.6 b	413 a	62 a
Sources of variation		df	-----------------------	-----------------------	Mean squares	-----------------------	-----------------------
Location (L)		1	5,633.3ns	1,716.0**	89.7**	1,500,607.7**	0.8ns
Error (a)		6	5,093.6	17.1	0.3	7,186.1	0.3
Genotype (G)		1	20,254.1*	11.0ns	24.9ns	1.7ns	1.1ns
L x G		1	630.8ns	46.0*	0.1ns	37,129.7ns	16.3**
Error (b)		6	2,158.4	7.8	5.1	7,899.9	0.2
Year (Y)		2	132,386.5**	333.4**	466.2**	116,929.0**	24.8**
L x Y		2	104,841.0**	190.4**	191.5**	100,026.6**	10.9**
G x Y		2	10,702.5ns	40.9ns	3.3ns	28,085.7ns	3.1*
L x G x Y		2	25,879.9**	112.1**	10.6*	4,542.1ns	2.5ns
Error (c)		24	4,218.2	13.3	2.3	9,349.4	0.6

*, ** Significant at 5% and 1% levels, respectively; ns = not significant at 5%.

\+ Means followed by the same letter, within years, for the same location, are not different at the 5% level of significance, using the Student-Newman-Keuls' Test.