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Variety Mixtures for Reduced Input Barley

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Summary

Variety mixtures may lessen competition among plants and reduce effects of stress particularly in environments where resources are limiting. Mixtures of four barley varieties were grown under low input conditions at the Maricopa Agricultural Center. The barley varieties seeded were Barcott, Solum, Solar, and an experimental low input line designated Entry 9. The highest yields were not obtained with mixtures in this experiment, but rather when the varieties were grown alone. Barcott and Entry 9 decreased yield when part of the mixture more than Solum or Solar. When Solum was grown in a mixture rather than alone, test weight and lodging were improved, but yield was decreased.

Introduction

It is possible to obtain higher yields with mixtures of crops than with individual crops planted alone. Intercropping, as this practice is called, is not practical with mechanical harvesting and is used mainly in the tropics with crops that are harvested by hand. If a single species is planted, such as wheat or barley, varieties with differing characteristics may be mixed and harvested mechanically. Variety mixtures can outperform solid plantings of single varieties if the varieties in the mixtures are sufficiently different in characteristics including height, rooting pattern, or maturity. The problem with crops where all plants are similar is that they compete more intensely with each other for resources such as water, light, and fertilizer. An example of a successful variety mixture in Arizona is Aldente, a mixture of WestBred 881 and Turbo that combined some of the quality of WestBred 881 with the yield potential of Turbo. Variety mixtures may lessen competition among plants and reduce effects of stress particularly in environments where resources are limiting.

Procedure

Mixtures of four barley varieties were grown under low input conditions at the Maricopa Agricultural Center. The barley varieties included in the mixtures were: 1) Barcott – a high input barley, 2) Solum – a low input barley, 3) Solar – a low input barley, and 4) Entry 9 – a low input 2-row barley (the other three varieties are 6-row barleys). Various proportions of these barley varieties were included in 15 mixtures, and sown at rates of 1000 or 2000 seeds per plot or 12 or 24 seeds/ft² (assuming seeded area of 49 inches by 20 ft) corresponding to about 40 and 80 lbs seed per acre (Table 1). The experimental design consisted of 2 simplexes (groups of 15 mixtures) and 2 initial densities.

The experiment was conducted in Field 1, Border 18 at the Maricopa Agricultural Center during the 2005-2006 growing season. The soil type was a Casa Grande sandy loam. The previous crop was bermudagrass. The surface 6 inches of soil was sampled before planting and contained 31.0 ppm NO₃-N and 5.4 ppm P. The mixtures were planted in 5 ft x 20 ft plots on November 30, 2005. Seven rows spaced 7 inches apart were planted. The irrigation system was border flood, an irrigation to germinate the seed was applied on December 2, and an additional irrigation was applied on February 17. Fertilizer was applied preplant as ammonium phosphate sulfate (16-20-0) at a rate of 48 lbs N/acre and 60 lbs P₂O₅/acre. Nitrogen fertilizer was applied at of rate of 50 lbs N/acre as urea (46-0-0) on February 17 prior to the irrigation.

Stand counts were made on December 29 from four areas with dimensions of 2 ft long and 5 rows wide (23.3 ft²). On January 16 at the 5-leaf stage, 20 plants were sampled per plot and the plant area and total dry weight were measured. Whole plants including crowns were dug up and removed on April 19 from an area 2 rows wide by 16

feet long. The individual varieties in each mixture were separated based on distinguishing characteristics. Barcott is short, Solum has a rough awn, Solar has a smooth awn, and Entry 9 has 2-row head type. The following was recorded for each variety: plant height, number of plants, stems per plant (from 10 plants), head per plant (from 10 plants), total plant weight, and grain weight. On May 11, lodging was noted and a small plot combine was used to harvest the grain. Barley grain samples were cleaned by running through a head thresher. Test weight was determined from these cleaned samples using a 1-pint container. Seed weight was determined from a 10 g sample of grain.

Discussion

The barley varieties were chosen based on differences in plant characteristics. Barcott is the shortest variety, and the others are roughly similar in height (Table 6). Solum is the earliest in maturity, and the others mature around the same time (Table 2). Our hypothesis was that differences in these characteristics would reduce plant competition and potentially increase grain yield. However, the highest yields were not obtained with mixtures in this experiment, but rather when the varieties were grown alone. Three of the highest four yields were obtained when the varieties were grown alone (Table 3). This could have occurred because Entry 9 dragged down the yield of the others. This variety had low grain yield in this study, but also was a vigorous plant with a low grain to straw ratio that may have competed with the other varieties without contributing a commensurate share of grain yield. Another possibility is that the varieties had a negative impact on each other in a mixture, such as a slight allelopathic reaction.

One of the benefits of mixtures is that negative characteristics of certain varieties can be lessened by the presence of other varieties. For example, negative characteristics of Solum is low test weight and high lodging potential. Solum planted alone had a test weight of 46.5 lbs/bu and lodging of 40%, but when planted with Solar predominantly (10% Barcott, 40% Solum, 40% Solar, 10% Entry 9), the test weight was increased to 48.0 lbs/bu and lodging decreased to 15%. However, the yield was also reduced by 14%.

Stand and initial growth was least for Barcott and greatest for Entry 9 (especially at the higher seeding rate), and intermediate for Solum and Solar (Table 4). Thus, the composition of the mixtures refers to the amount seeded and not necessarily the amount established. At harvest, there were fewer plants of Barcott and more plants of Entry 9 in the mixtures than were seeded, while the percentage of Solum and Solar seeded and harvested were similar (Table 5). The same trend was measured for stem number (Table 7) and head number (Table 8). Entry 9 was also the best competitor in the mixture in terms of total plant yield, Barcott was the worst competitor, and Solar was more competitive than Solum (Table 9). However, since Entry 9 had a low grain to straw ratio, it did not dominate the mixtures in terms of grain yield (Table 10). Solar contributed most to the grain yield of the mixtures, followed by Entry 9, Solum, and Barcott.

Mixtures may have potential for increased yield compared to single varieties, but this research has not provided any evidence for this effect. We have shown that some varieties do better than others in a mixture. Barcott, the short variety probably did poorly because it was shaded by the taller varieties even though it was earlier in maturity. Entry 9 was not productive when planted alone, and decreased yield of the mixtures it was part of. Perhaps the key to increased productivity of mixtures is extensive testing and careful selection of components of the mixture.

Acknowledgments

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Table 1. Seeding rate and number of seed of each barley variety for the mixtures.

Seeding rate			Mixture	Mixture composition (seeds/plot)			
seeds/plot	seeds/ft ²	lbs seed/acre	Percentage of Barcott/Solum/Solar/Entry9	Barcott	Solum	Solar	Entry 9
1000	12	40	70/10/10/10	700	100	100	100
1000	12	40	10/70/10/10	100	700	100	100
1000	12	40	10/10/70/10	100	100	700	100
1000	12	40	10/10/10/70	100	100	100	700
1000	12	40	25/25/25/25	250	250	250	250
1000	12	40	40/40/10/10	400	400	100	100
1000	12	40	40/10/40/10	400	100	400	100
1000	12	40	40/10/10/40	400	100	100	400
1000	12	40	10/40/40/10	100	400	400	100
1000	12	40	10/40/10/40	100	400	100	400
1000	12	40	10/10/40/40	100	100	400	400
1000	12	40	100/0/0/0	1000	0	0	0
1000	12	40	0/100/0/0	0	1000	0	0
1000	12	40	0/0/100/0	0	0	1000	0
1000	12	40	0/0/0/100	0	0	0	1000
2000	24	80	70/10/10/10	1400	200	200	200
2000	24	80	10/70/10/10	200	1400	200	200
2000	24	80	10/10/70/10	200	200	1400	200
2000	24	80	10/10/10/70	200	200	200	1400
2000	24	80	25/25/25/25	500	500	500	500
2000	24	80	40/40/10/10	800	800	200	200
2000	24	80	40/10/40/10	800	200	800	200
2000	24	80	40/10/10/40	800	200	200	800
2000	24	80	10/40/40/10	200	800	800	200
2000	24	80	10/40/10/40	200	800	200	800
2000	24	80	10/10/40/40	200	200	800	800
2000	24	80	100/0/0/0	2000	0	0	0
2000	24	80	0/100/0/0	0	2000	0	0
2000	24	80	0/0/100/0	0	0	2000	0
2000	24	80	0/0/0/100	0	0	0	2000

Table 2. Heading, anthesis, and maturity for the barley varieties at two seeding rates.

	Seeding rate (lbs/acre)	Barcott	Solum	Solar	Entry 9
Heading	40	3/4	3/3	3/1	3/17
Anthesis	40	3/4	3/3	3/1	3/17
Maturity	40	4/13	4/5	4/14	4/14
Heading	80	3/4	3/2	3/2	3/17
Anthesis	80	3/4	3/2	3/2	3/17
Maturity	80	4/13	4/7	4/14	4/14

Table 3. Grain yield, test weight, seed weight, and lodging at harvest for barley mixtures.

Percentage of Barcott/Solum/Solar/Entry9 %	40 lbs seed/acre				80 lbs seed/acre				Average			
	Grain yield	Test weight	Seed weight	Lodg- ing	Grain yield	Test weight	Seed weight	Lodg- ing	Grain yield	Test weight	Seed weight	Lodg- ing
	lbs/A	lbs/bu	mg	%	lbs/A	lbs/bu	mg	%	lbs/A	lbs/bu	mg	%
70/10/10/10	3388	45.6	34.5	10	3200	46.3	31.9	50	3294	46.0	33.2	30
10/70/10/10	3415	46.1	34.5	5	3576	46.6	34.2	0	3496	46.4	34.3	3
10/10/70/10	3307	49.2	33.7	40	3711	48.8	33.8	25	3509	49.0	33.8	33
10/10/10/70	2985	50.2	34.1	5	2554	49.5	32.0	0	2770	49.9	33.0	3
25/25/25/25	3496	49.0	35.2	10	3415	47.7	33.1	10	3455	48.3	34.1	10
40/40/10/10	3254	46.7	33.6	0	3469	47.5	34.7	20	3361	47.1	34.1	10
40/10/40/10	3522	47.7	33.5	10	3684	49.5	34.4	15	3603	48.6	34.0	13
40/10/10/40	2823	47.3	31.9	15	2850	47.4	30.3	2	2837	47.3	31.1	9
10/40/40/10	3684	48.1	35.5	15	3334	47.8	31.2	15	3509	48.0	33.4	15
10/40/10/40	2904	47.6	33.0	10	3307	48.8	34.2	10	3106	48.2	33.6	10
10/10/40/40	3092	49.3	33.7	2	3469	48.8	31.8	5	3280	49.1	32.7	4
100/0/0/0	3657	44.3	32.5	5	3603	43.1	29.1	5	3630	43.7	30.8	5
0/100/0/0	3926	45.6	37.6	20	4195	47.4	36.8	60	4060	46.5	37.2	40
0/0/100/0	3791	51.1	37.7	7	4114	49.9	34.9	10	3953	50.5	36.3	9
0/0/0/100	2743	49.5	31.1	0	2501	48.7	28.1	10	2622	49.1	29.6	5
All	3332	47.8	34.1	10	3399	47.8	32.7	16	3366	47.8	33.4	13

Table 4. Stand on December 29, and plant weight and PAI (plant area index) on January 16 at the 5-leaf stage.

Percentage of Barcott/Solum/Solar/Entry 9 %	40 lbs seed/acre			80 lbs seed/acre			Average		
	Stand	Plant weight	PAI	Stand	Plant weight	PAI	Stand	Plant weight	PAI
	plants/ft ²	lbs/A		plants/ft ²	lbs/A		plants/ft ²	lbs/A	
70/10/10/10	8.3	293	0.63	11.5	395	1.10	9.9	344	0.86
10/70/10/10	9.7	355	0.79	15.0	582	1.49	12.3	469	1.14
10/10/70/10	9.9	453	1.07	15.4	808	2.26	12.6	630	1.66
10/10/10/70	11.1	462	1.06	20.4	682	1.85	15.8	572	1.45
25/25/25/25	8.0	355	0.79	15.9	528	1.42	12.0	442	1.10
40/40/10/10	7.9	282	0.64	12.7	533	1.42	10.3	408	1.03
40/10/40/10	10.0	313	0.74	16.9	568	1.54	13.5	441	1.14
40/10/10/40	9.9	465	1.13	14.2	423	1.22	12.0	444	1.17
10/40/40/10	8.3	461	1.17	13.7	375	0.99	11.0	418	1.08
10/40/10/40	10.5	439	1.07	16.0	468	1.31	13.3	453	1.19
10/10/40/40	11.4	498	1.20	15.5	514	1.48	13.4	506	1.34
100/0/0/0	7.4	186	0.44	13.3	231	0.68	10.4	209	0.56
0/100/0/0	8.3	336	0.83	12.6	375	0.95	10.4	355	0.89
0/0/100/0	10.1	406	1.07	12.3	507	1.47	11.2	457	1.27
0/0/0/100	9.9	371	0.99	21.2	646	1.85	15.6	508	1.42
All	9.4	379	0.91	15.1	509	1.40	12.2	444	1.15

Table 5. Number of plants of each variety at harvest as a percentage of the total mixture.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Plant number of each variety at harvest as a percentage of total											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Barcott	Solum	Solar	Entry9	Barcott	Solum	Solar	Entry 9	Barcott	Solum	Solar	Entry 9
%	%				%				%			
70/10/10/10	49	15	14	23	49	13	16	23	49	14	15	23
10/70/10/10	7	59	6	27	6	66	9	20	7	63	8	23
10/10/70/10	2	8	75	15	2	8	70	20	2	8	72	18
10/10/10/70	5	5	6	85	7	6	7	80	6	5	7	82
25/25/25/25	9	25	26	40	7	21	22	50	8	23	24	45
40/40/10/10	23	32	23	22	23	40	14	24	23	36	18	23
40/10/40/10	22	13	44	21	15	49	14	21	19	31	29	21
40/10/10/40	17	8	11	64	16	7	9	69	16	7	10	66
10/40/40/10	5	34	40	21	8	20	57	15	6	27	49	18
10/40/10/40	8	22	12	58	10	24	10	56	9	23	11	57
10/10/40/40	4	9	29	58	3	3	32	62	3	6	31	60
100/0/0/0	100	0	0	0	100	0	0	0	100	0	0	0
0/100/0/0	0	100	0	0	0	100	0	0	0	100	0	0
0/0/100/0	0	0	100	0	0	0	100	0	0	0	100	0
0/0/0/100	0	0	0	100	0	0	0	100	0	0	0	100
Average	14	21	26	39	13	23	24	40	13	22	25	40

Table 6. Plant height of each variety in the various mixtures at harvest.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Plant height of each variety at harvest											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Barcott	Solum	Solar	Entry9	Barcott	Solum	Solar	Entry 9	Barcott	Solum	Solar	Entry 9
%	inches				inches				inches			
70/10/10/10	24	29	34	37	22	30	33	32	23	29	33	34
10/70/10/10	24	30	34	34	23	30	34	35	23	30	34	34
10/10/70/10	24	33	35	36	21	32	35	37	22	33	35	36
10/10/10/70	21	31	35	36	23	27	33	31	22	29	34	34
25/25/25/25	23	34	35	36	20	33	33	31	21	33	34	33
40/40/10/10	24	33	36	36	22	33	36	37	23	33	36	37
40/10/40/10	24	32	38	37	27	37	40	39	25	34	39	38
40/10/10/40	30	36	40	40	26	32	38	33	28	34	39	36
10/40/40/10	30	37	40	36	24	31	34	34	27	34	37	35
10/40/10/40	28	36	39	39	25	37	36	35	27	37	37	37
10/10/40/40	23	32	36	35	22	34	36	37	22	33	36	36
100/0/0/0	29	---	---	---	26	---	---	---	27	---	---	---
0/100/0/0	---	38	---	---	---	30	---	---	---	34	---	---
0/0/100/0	---	---	34	---	---	---	33	---	---	---	33	---
0/0/0/100	---	---	---	36	---	---	---	36	---	---	---	36
All	25	33	36	37	23	32	35	35	24	33	36	36

Table 7. Number of stems of each variety at harvest as a percentage of the total mixture.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Stem number for each variety at harvest as a percentage of the total											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Bar- cott	Solum	Solar	Entry9	Bar- cott	Solum	Solar	Entry 9	Ba- rcott	Solum	Solar	Entry 9
%	%				%				%			
70/10/10/10	44	20	14	21	44	15	16	26	44	18	15	24
10/70/10/10	5	60	7	29	6	52	9	33	6	56	8	31
10/10/70/10	2	7	68	22	1	5	74	20	2	6	71	21
10/10/10/70	3	3	6	89	4	4	6	85	3	4	6	87
25/25/25/25	7	17	23	54	4	14	19	63	5	15	21	58
40/40/10/10	26	26	20	28	16	39	12	33	21	32	16	31
40/10/40/10	19	9	49	23	12	58	12	19	15	33	31	21
40/10/10/40	10	4	9	77	12	5	6	77	11	4	7	77
10/40/40/10	4	29	48	20	5	14	62	20	4	21	55	20
10/40/10/40	6	14	9	71	7	16	9	68	6	15	9	70
10/10/40/40	2	9	30	58	2	3	27	69	2	6	28	63
100/0/0/0	100	0	0	0	100	0	0	0	100	0	0	0
0/100/0/0	0	100	0	0	0	100	0	0	0	100	0	0
0/0/100/0	0	0	100	0	0	0	100	0	0	0	100	0
0/0/0/100	0	0	0	100	0	0	0	100	0	0	0	100
Average	12	18	26	45	10	20	23	47	11	19	24	46

Table 8. Number of heads of each variety at harvest as a percentage of the total mixture.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Head number for each variety at harvest as a percentage of the total											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Bar- cott	Solum	Solar	Entry9	Bar- cott	Solum	Solar	Entry 9	Ba- rcott	Solum	Solar	Entry 9
%	%				%				%			
70/10/10/10	1	43	22	16	20	48	14	16	22	45	18	16
10/70/10/10	2	6	60	6	28	6	52	9	33	6	56	8
10/10/70/10	3	2	7	73	18	1	5	77	16	2	6	75
10/10/10/70	4	3	4	7	87	5	6	8	82	4	5	7
25/25/25/25	5	8	19	23	50	4	11	22	64	6	15	22
40/40/10/10	6	30	24	21	26	18	46	14	22	24	35	18
40/10/40/10	7	22	8	53	17	11	61	13	15	17	34	33
40/10/10/40	8	11	4	9	75	14	4	8	75	13	4	8
10/40/40/10	9	4	31	46	19	6	16	60	19	5	24	53
10/40/10/40	10	5	13	10	73	12	18	9	62	8	16	9
10/10/40/40	11	3	11	31	56	2	3	32	63	3	7	31
100/0/0/0	100	0	0	0	100	0	0	0	100	0	0	0
0/100/0/0	0	100	0	0	0	100	0	0	0	100	0	0
0/0/100/0	0	0	100	0	0	0	100	0	0	0	100	0
0/0/0/100	0	0	0	100	0	0	0	100	0	0	0	100
Average	12	18	27	43	11	21	24	43	12	20	26	43

Table 9. Total plant yield of each variety at harvest as a percentage of the total mixture.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Total plant yield for each variety at harvest as a percentage of the total											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Bar- cott	Solum	Solar	Entry9	Bar- cott	Solum	Solar	Entry 9	Ba- rcott	Solum	Solar	Entry 9
%	%				%				%			
70/10/10/10	38	18	21	23	39	17	21	23	39	18	21	23
10/70/10/10	5	64	7	25	6	63	10	20	6	64	8	23
10/10/70/10	1	4	74	21	1	5	76	18	1	5	75	19
10/10/10/70	2	5	12	81	5	6	11	78	3	6	11	80
25/25/25/25	4	25	30	41	5	18	28	50	5	21	29	45
40/40/10/10	19	31	27	23	15	42	18	26	17	36	23	24
40/10/40/10	13	14	57	17	9	14	59	19	11	14	58	18
40/10/10/40	9	7	14	71	11	8	14	68	10	7	14	69
10/40/40/10	2	33	47	18	5	21	60	14	4	27	53	16
10/40/10/40	5	17	18	60	7	23	12	58	6	20	15	59
10/10/40/40	2	11	36	51	2	4	42	52	2	8	39	52
100/0/0/0	100	0	0	0	100	0	0	0	100	0	0	0
0/100/0/0	0	100	0	0	0	100	0	0	0	100	0	0
0/0/100/0	0	0	100	0	0	0	100	0	0	0	100	0
0/0/0/100	0	0	0	100	0	0	0	100	0	0	0	100
Average	9	21	31	39	10	20	32	39	9	21	31	39

Table 10. Grain yield of each variety at harvest as a percentage of the total mixture.

Percentage seeded of Barcott/Solum/Solar/Entry 9	Grain yield for each variety at harvest as a percentage of the total											
	40 lbs seed/acre				80 lbs seed/acre				Average			
	Bar- cott	Solum	Solar	Entry9	Bar- cott	Solum	Solar	Entry 9	Ba- rcott	Solum	Solar	Entry 9
%	%				%				%			
70/10/10/10	41	22	22	16	41	20	24	15	41	21	23	15
10/70/10/10	5	72	7	16	6	70	10	14	6	71	8	15
10/10/70/10	1	6	81	11	1	6	81	12	1	6	81	12
10/10/10/70	3	9	17	72	5	10	16	69	4	9	17	70
25/25/25/25	5	32	33	31	6	23	31	41	5	27	32	36
40/40/10/10	18	38	28	17	14	49	19	18	16	44	24	17
40/10/40/10	13	17	59	12	9	17	61	13	11	17	60	13
40/10/10/40	10	9	18	63	12	10	20	58	11	9	19	61
10/40/40/10	2	38	48	12	5	24	61	9	4	31	54	11
10/40/10/40	6	21	21	52	10	29	13	48	8	25	17	50
10/10/40/40	2	16	41	41	3	6	50	42	2	11	45	42
100/0/0/0	100	0	0	0	100	0	0	0	100	0	0	0
0/100/0/0	0	100	0	0	0	100	0	0	0	100	0	0
0/0/100/0	0	0	100	0	0	0	100	0	0	0	100	0
0/0/0/100	0	0	0	100	0	0	0	100	0	0	0	100
Average	10	25	34	31	10	24	35	31	10	25	35	31

