

Row Spacing and Direction Effects on Yield, Water Use, Tillering and Light Interception of One-Irrigation Barley

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Summary

The one-irrigation barley variety Solum is adapted to wide row spacing, and sometimes yields higher in wide compared to narrow spacing. This study was initiated to determine the effect of row spacing and direction on Solum water use and yield components. Solum barley was planted at the Marana Agricultural Center at 6, 12, 18, and 24 inch row spacings in north-south and east-west rows in late November and late-February or early March over 2 growing seasons. Row spacing and direction had little effect on yield and yield components, water use, tillering, and light interception. Nevertheless, in some instances narrow row spacing resulted in more heads that were smaller and had lighter kernels than wide row spacing. We measured greater soil water depletion for the narrow row spacings at the late planting date one year due to greater stem density. The narrow rows intercepted more light than wide rows and the wide rows intercepted more light at solar noon in east-west compared to north-south rows. We were not able to confirm the theory that soil water is conserved in wide rows for use at more critical stages later in the season.

Introduction

One-irrigation barley is able to grow and produce relatively plump kernels with a single irrigation near planting. Seco and Solum are one-irrigation barley varieties that have been released in the past 10 years. Previous work has shown that one-irrigation barley performs well in row spacings of 12 to 18 inches (Ottman et al., 1988). One-irrigation barley varieties perform well in wide rows because they are tall and produce many tillers. Also, it has been suggested that soil moisture depletion is delayed in wide rows and moisture is conserved for more critical stages later in the season. Row direction and planting date provide an additional complication to row spacing. For example, in rows running east-west and planting early, direct sunlight does not reach the soil surface for much of the season because of the oblique angle of the sun in the winter.

The purpose of this study is to determine the effect of row spacing and direction on one-irrigation barley water use and yield components.

Procedure

Experiments were conducted at the Marana Agricultural Center on a Pima clay loam soil. The one-irrigation barley variety Solum was seeded with a single row planter at a rate of 10 seeds per square foot, or about 44 pounds of seed per acre. The seed was planted at 4 row spacings (6, 12, 18, and 24 inches), 2 row directions (north-south and east-west), two planting dates (early and late), and two growing seasons (1991 and 1992). The planting dates for the 1991 growing season were 20 Nov 90 and 20 Feb 91 and the planting dates for the 1992 growing season were 20 Nov 91 and 03 Mar 92. Fertilizer was applied preplant at a rate of 92 lbs N/A and 60 lbs P2O5/A as urea and 11-52-0 (1991) or 18-46-0 (1992). A single border flood irrigation was applied at these planting dates and the plots received no more irrigation after planting. Effective rainfall for the various planting dates was: 6.60 inches (20 Nov 90), 1.55 inches (20 Feb 91), 9.53 inches (20 Nov 91), and 7.52 inches (03 Mar 92). The experimental design was a randomized complete block with 8 treatments (4 row spacing and 2 row directions) and 4 replications. The plots were 10 ft by 10 ft in size.

Soil moisture depletion, stem number, and light interception were measured on a weekly basis. A neutron probe access tube was installed in each plot within the rows in 1991 and both within and between rows in 1992. Soil moisture depletion was calculated from neutron probe readings in 1 ft increments to 5 ft. Stem number was calculated from an area 2 ft wide and 2 ft long except for the 18 inch row spacing where the width of the area was 1.5 ft. Light interception was measured within an hour of solar noon using a sunflecks ceptometer with a sensing surface of 7/16 inch by 34.5 inches placed at the soil surface. Plants were harvested from the same area stem counts were measured. The following was determined at harvest: total biomass, grain yield, heads per square foot, kernels per head (by calculation), kernel weight, and harvest index.

Results and Discussion

Row spacing and direction had little effect on yield and yield components (Tables 1a-d). Total plant yield was highest at the narrow row spacing for the 20 Feb 91 planting date but not the other planting dates. Grain yield was not affected by row spacing or direction at any planting date. Nevertheless, relative yields averaged over the row spacing was 105% (6 inch), 99% (12 inch), 100% (18 inch) and 96% (24 inch) and relative yields averaged over the row directions were 100.3% (north-south) and 99.7% (east-west). The narrow row spacings had more heads than wider spacings in some cases, but the heads were smaller and the kernels lighter. Harvest index was not affected by row spacing or direction.

We were not able to measure any effects of row spacing and direction on soil moisture depletion during the 1992 growing season, but some interesting effects were measured during the 1991 growing season (Tables 2a-d). A row spacing by direction interaction was measured during the early part of grain fill for the 20 November 90 planting date where narrow rows used less water than wider rows in a north-south row direction, but more water in a east-west row direction. At the 20 Feb 91 planting date, a row spacing by direction interaction was also detected but in an opposite trend to the earlier planting date. At the 20 Feb 91 planting date, we also measured greater soil water depletion for narrow compared to wide rows.

Stem density was not affected by row spacing or direction except for the 20 Feb 91 planting date where narrow rows had higher stem density than wide rows (Tables 3a-d). Stem density can account for the differences in water use observed at this planting date mentioned in the paragraph above.

The narrow rows intercepted more light than the wide rows as expected (Tables 4a-d). The wide rows intercepted more light at solar noon in east-west rows than north-south rows.

The one-irrigation barley variety Solum is adapted to a wide range of row spacings. The yield advantage of row spacings of 12 to 18 inches measured in previous studies was not obtained in this one. The pattern of water use, tillering, and light interception were somewhat similar, except in a few instances, regardless of row spacing since Solum tillers well and covers the soil surface despite wide rows or low initial stand.

References

Ottman, M. J., R. T. Ramage, and G. W. Thacker. 1988. Cultural practices of one-irrigation barley at Marana, 1988. Forage and Grain. pp. 47-52. Univ. Ariz. Coop. Ext. Ag. Exp. Stn. Report Series P-74, Tucson.

Acknowledgments

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Table 1a. Yield and yield components as influenced by row spacing and direction for the 20 Nov 90 planting date.

Row Direction	Row Spacing inches	Total Yield lbs/A	Grain Yield lbs/A	Head Density heads/ft ²	Head Size kernels/head	Kernel Weight mg	Harvest Index %
NS	6	10065	4959	19.4	59.4	43.5	47.4
NS	12	8658	4180	19.5	55.8	40.8	48.0
NS	18	10825	5442	23.2	55.7	43.9	50.6
NS	24	7967	3896	16.3	58.0	41.9	48.1
EW	6	9515	4760	22.0	50.6	42.7	49.6
EW	12	7009	3441	14.8	56.7	44.2	49.3
EW	18	8446	4114	18.1	55.8	42.3	48.8
EW	24	9018	4390	18.0	58.5	43.0	48.5
--	6	9790	4860	20.7	55.0	43.1	48.5
--	12	7834	3811	17.1	56.3	42.5	48.6
--	18	9636	4778	20.7	55.7	43.1	49.7
--	24	8493	4143	17.2	58.2	42.4	48.3
NS	--	9379	4619	19.6	57.2	42.5	48.5
EW	--	8497	4176	18.2	55.4	43.1	49.0
Spacing		NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS
Spacing*Direction		NS	NS	NS	NS	NS	NS

Table 1b. Yield and yield components as influenced by row spacing and direction for the 20 Feb 91 planting date.

Row Direction	Row Spacing inches	Total Yield lbs/A	Grain Yield lbs/A	Head Density heads/ft ²	Head Size kernels/head	Kernel Weight mg	Harvest Index %
NS	6	4587	1974	24.0	26.9	31.2	42.3
NS	12	4484	2131	19.8	28.4	39.0	47.1
NS	18	3481	1587	16.8	27.2	36.5	45.5
NS	24	3832	1858	15.8	29.6	41.8	48.7
EW	6	4938	2303	24.2	28.8	34.2	46.6
EW	12	3858	1701	18.8	28.2	33.5	43.7
EW	18	3857	1740	16.6	27.7	39.0	44.7
EW	24	3815	1723	16.0	27.9	39.8	44.7
--	6	4762	2138	24.1	27.9	32.7	44.4
--	12	4171	1916	19.3	28.3	36.2	45.4
--	18	3669	1663	16.7	27.4	37.8	45.1
--	24	3823	1791	15.9	28.8	40.8	46.7
NS	--	4096	1887	19.1	28.0	37.1	45.9
EW	--	4117	1867	18.9	28.1	36.6	44.9
Spacing		+	NS	**	*	NS	NS
Direction		NS	NS	NS	NS	NS	NS
Spacing*Direction		NS	NS	NS	NS	NS	NS

Table 1c. Yield and yield components as influenced by row spacing and direction for the 20 Nov 91 planting date.

Row Direction	Row Spacing inches	Total Yield lbs/A	Grain Yield lbs/A	Head Density heads/ft ²	Head Size kernels/head	Kernel Weight mg	Harvest Index %
NS	6	11149	3749	23.9	43.8	37.3	33.4
NS	12	10763	3725	23.7	45.9	35.8	34.7
NS	18	8981	2981	17.7	48.0	36.9	33.3
NS	24	10553	3248	21.1	41.3	39.3	30.8
EW	6	10374	3313	23.0	42.0	35.9	31.9
EW	12	11836	3870	24.8	44.3	37.1	32.9
EW	18	10689	3538	22.1	43.3	38.4	33.2
EW	24	10596	3480	21.2	42.2	40.4	32.5
--	6	10762	3531	23.5	42.9	36.6	32.6
--	12	11299	3797	24.3	45.1	36.5	33.8
--	18	9835	3260	19.9	45.7	37.7	33.2
--	24	10574	3364	21.1	41.7	39.9	31.7
NS	--	10361	3426	21.6	44.8	37.3	33.0
EW	--	10874	3317	21.4	44.3	37.0	32.7
	Spacing	NS	NS	+	NS	*	NS
	Direction	NS	NS	NS	NS	NS	NS
	Spacing*Direction	NS	NS	NS	NS	NS	NS

Table 1d. Yield and yield components as influenced by row spacing and direction for the 03 Mar 92 planting date.

Row Direction	Row Spacing inches	Total Yield lbs/A	Grain Yield lbs/A	Head Density heads/ft ²	Head Size kernels/head	Kernel Weight mg	Harvest Index %
NS	6	3681	960	18.1	29.4	19.5	26.6
NS	12	3261	953	14.8	36.6	18.5	29.3
NS	18	3189	1058	15.8	36.6	19.1	33.2
NS	24	3094	849	17.1	29.1	17.7	27.8
EW	6	3719	902	19.5	27.3	17.5	24.2
EW	12	3295	997	15.2	36.0	19.1	30.4
EW	18	3489	1088	17.7	32.7	19.6	31.2
EW	24	3393	1037	17.3	32.8	19.1	30.6
--	6	3700	931	18.8	28.4	18.5	25.4
--	12	3278	975	15.0	36.3	18.8	29.9
--	18	3339	1073	16.7	34.7	19.4	32.2
--	24	3244	943	17.2	31.0	18.4	29.2
NS	--	3306	955	16.4	32.9	18.7	29.2
EW	--	3474	1006	17.4	32.2	18.8	29.1
	Spacing	NS	NS	NS	*	NS	NS
	Direction	NS	NS	NS	NS	NS	NS
	Spacing*Direction	NS	NS	NS	NS	NS	NS

Table 2a. Cumulative soil moisture depletion to a depth of 5 ft. from 04 January to various time periods as influenced by row spacing and direction for the 20 Nov 90 planting date.

Row		Cumulative Soil Moisture Depletion (5 ft.)											
Direction	Row Spacing	10Jan	19Jan	30Jan	08Feb	13Feb	25Feb	05Mar	25Mar	29Mar	12Apr	19Apr	01May
	inches	inches											
NS	6	1.00	1.66	2.18	2.60	2.88	3.81	4.72	6.01	6.77	8.13	9.33	10.49
NS	12	0.92	1.81	2.26	2.74	2.95	4.16	5.10	6.87	7.62	8.97	9.99	11.05
NS	18	0.86	1.64	2.20	2.59	2.64	3.88	4.91	6.59	7.39	8.78	9.89	10.79
NS	24	0.99	1.72	2.18	2.60	2.90	3.80	4.97	6.60	7.39	8.79	9.71	10.60
EW	6	0.84	1.74	2.32	2.81	2.96	4.13	5.15	7.06	7.83	9.35	10.13	10.64
EW	12	0.94	1.67	2.22	2.60	2.81	3.86	4.82	6.41	7.23	8.52	9.62	10.48
EW	18	0.83	1.67	2.14	2.56	2.79	3.77	4.81	6.42	7.06	8.38	9.43	10.30
EW	24	0.80	1.51	2.02	2.38	2.73	3.62	4.68	6.17	7.00	8.42	9.52	10.49
--	6	0.92	1.70	2.25	2.71	2.92	3.97	4.93	6.54	7.30	8.74	9.73	10.57
--	12	0.93	1.74	2.24	2.67	2.88	4.01	4.96	6.64	7.43	8.74	9.80	10.77
--	18	0.84	1.65	2.17	2.58	2.72	3.83	4.86	6.50	7.23	8.58	9.66	10.55
--	24	0.90	1.61	2.10	2.49	2.81	3.71	4.82	6.39	7.20	8.60	9.62	10.54
NS	--	0.94	1.71	2.20	2.63	2.84	3.91	4.93	6.52	7.30	8.67	9.73	10.73
EW	--	0.85	1.65	2.18	2.59	2.83	3.85	4.86	6.52	7.28	8.67	9.68	10.48
Spacing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spacing*Direct.		NS	NS	NS	NS	NS	NS	NS	NS	+	+	NS	NS

Table 2b. Cumulative soil moisture depletion to a depth of 5 ft. from 29 March to various time periods as influenced by row spacing and direction for the 20 Feb 91 planting date.

Row		Cumulative Soil Moisture Depletion (5 ft.)							
Direction	Row Spacing	03Apr	09Apr	17Apr	01May	08May	15May	22May	
	inches	inches							
NS	6	1.30	2.01	2.81	4.75	6.17	6.94	7.40	
NS	12	1.22	1.79	2.53	4.62	6.12	6.98	7.49	
NS	18	1.21	1.87	2.41	4.20	5.77	6.44	6.88	
NS	24	1.23	1.70	2.27	4.15	5.47	6.33	6.94	
EW	6	1.18	1.81	2.53	4.56	5.95	6.80	7.40	
EW	12	1.29	1.87	2.55	4.56	5.91	6.74	7.19	
EW	18	1.26	1.68	2.35	4.28	5.66	6.48	6.97	
EW	24	1.28	1.96	2.42	4.19	5.65	6.44	6.84	
--	6	1.24	1.91	2.67	4.66	6.06	6.87	7.40	
--	12	1.25	1.83	2.54	4.59	6.01	6.86	7.34	
--	18	1.24	1.77	2.38	4.24	5.71	6.46	6.92	
--	24	1.25	1.83	2.35	4.17	5.56	6.39	6.89	
NS	--	1.24	1.84	2.51	4.43	5.88	6.67	7.18	
EW	--	1.25	1.83	2.46	4.40	5.79	6.62	7.10	
Spacing		NS	NS	*	*	+	*	*	
Direction		NS	NS	NS	NS	NS	NS	NS	
Spacing*Direction		NS	*	NS	NS	NS	NS	NS	

Table 2c. Cumulative soil moisture depletion to a depth of 5 ft. from 16 December to various time periods as influenced by row spacing and direction for the 20 Nov 91 planting date.

Row		Cumulative Soil Moisture Depletion (5 ft.)											
Direction	Row Spacing	23Dec	16Jan	23Jan	29Jan	04Feb	18Feb	25Feb	11Mar	24Mar	01Apr	08Apr	22Apr
	inches	inches											
NS	6	0.59	2.11	2.52	3.17	3.69	5.61	6.37	8.57	10.04	10.85	11.82	12.57
NS	12	0.65	2.06	2.49	3.25	3.66	5.50	6.30	8.33	9.84	10.81	11.64	12.46
NS	18	0.63	2.13	2.76	3.43	3.91	5.92	6.69	8.64	10.05	10.86	11.74	12.65
NS	24	0.52	2.09	2.47	3.10	3.65	5.56	6.44	8.52	9.84	10.87	11.67	12.39
EW	6	0.73	2.27	2.66	3.41	4.00	5.62	6.46	8.56	9.86	10.78	11.65	12.43
EW	12	0.63	2.06	2.57	3.22	3.76	5.78	6.54	8.57	10.08	10.94	11.81	12.67
EW	18	0.47	2.21	2.70	3.44	3.92	5.91	6.67	8.66	10.10	10.89	11.80	12.58
EW	24	0.51	2.13	2.67	3.34	3.90	5.92	6.71	8.75	10.21	11.07	11.90	12.63
--	6	0.66	2.19	2.59	3.29	3.85	5.61	6.42	8.57	9.95	10.81	11.73	12.50
--	12	0.64	2.06	2.53	3.24	3.71	5.64	6.42	8.45	9.96	10.87	11.73	12.57
--	18	0.55	2.17	2.73	3.44	3.92	5.92	6.68	8.65	10.07	10.87	11.77	12.61
--	24	0.51	2.11	2.57	3.22	3.77	5.74	6.57	8.64	10.02	10.97	11.78	12.51
NS	--	0.60	2.10	2.56	3.24	3.73	5.65	6.45	8.52	9.94	10.85	11.72	12.52
EW	--	0.58	2.17	2.65	3.35	3.90	5.81	6.60	8.64	10.06	10.92	11.79	12.58
Spacing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spacing*Direct.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2d. Cumulative soil moisture depletion to a depth of 5 ft. from 13 March to various time periods as influenced by row spacing and direction for the 03 Mar 92 planting date.

Row		Cumulative Soil Moisture Depletion (5 ft.)							
Direction	Row Spacing	23Mar	31Mar	14Apr	21Apr	27Apr	05May	14May	27May
	inches	inches							
NS	6	0.76	1.45	3.46	4.99	6.20	7.29	7.69	8.55
NS	12	0.78	1.48	3.54	4.78	6.13	7.32	7.75	8.60
NS	18	0.59	1.48	3.25	4.58	5.86	7.09	7.56	8.46
NS	24	0.61	1.43	3.35	4.74	6.00	7.17	7.67	8.44
EW	6	0.70	1.43	3.68	5.07	6.43	7.53	7.89	8.63
EW	12	0.54	1.36	3.56	4.95	6.16	7.33	7.84	8.75
EW	18	0.44	1.15	3.23	4.65	5.78	7.06	7.53	8.40
EW	24	0.79	1.63	3.53	4.82	6.21	7.44	7.90	8.80
--	6	0.73	1.44	3.57	5.03	6.32	7.41	7.79	8.59
--	12	0.66	1.42	3.55	4.86	6.15	7.33	7.79	8.67
--	18	0.52	1.31	3.24	4.62	5.82	7.08	7.54	8.43
--	24	0.70	1.53	3.44	4.78	6.10	7.30	7.79	8.62
NS	--	0.69	1.46	3.40	4.77	6.05	7.22	7.66	8.51
EW	--	0.62	1.39	3.50	4.87	6.15	7.34	7.79	8.64
Spacing		NS	NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS
Spacing*Direction		NS	NS	NS	NS	NS	NS	NS	NS

Table 3a. Stem density over time as influenced by row spacing and direction for the 20 Nov 90 planting date.

Row		Stem Density										
Direct- ion	Row Spacing	12Dec	04Jan	10Jan	19Jan	25Jan	30Jan	08Feb	13Feb	25Feb	05Mar	25Mar
		----- stems/ft ² -----										
NS	6	3.33	3.50	5.4	11.4	13.3	19.6	29.4	31.9	29.3	30.4	30.3
NS	12	3.50	3.75	6.8	8.2	13.5	14.4	29.2	28.3	28.3	28.6	27.2
NS	18	3.22	3.22	5.8	10.1	13.6	18.4	24.9	27.2	28.2	29.6	27.9
NS	24	4.08	4.00	6.7	11.3	13.5	21.3	25.1	25.3	23.8	25.8	25.0
EW	6	4.17	3.92	6.0	11.0	13.3	18.6	28.6	32.0	32.4	34.4	31.0
EW	12	2.58	2.75	3.8	6.2	10.4	12.6	18.3	21.8	22.8	23.3	22.3
EW	18	3.44	3.67	6.4	10.2	14.4	20.0	26.7	28.4	25.3	25.6	24.8
EW	24	3.00	2.75	6.3	8.3	11.7	14.9	19.6	21.3	17.6	21.9	21.5
--	6	3.75	3.71	5.7	11.2	13.3	19.1	29.0	32.0	30.8	32.4	30.7
--	12	3.04	3.25	5.3	7.2	12.0	13.5	23.7	25.1	25.6	26.0	24.7
--	18	3.33	3.44	6.1	10.2	14.0	19.2	25.8	27.8	26.8	27.6	26.3
--	24	3.54	3.38	6.5	9.8	12.6	18.1	22.3	23.3	20.7	23.9	23.3
NS	--	3.53	3.62	6.2	10.2	13.5	18.4	27.1	28.2	27.4	28.6	27.6
EW	--	3.30	3.27	5.6	8.9	12.4	16.5	23.3	25.9	24.5	26.3	24.9
Spacing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3b. Stem density over time as influenced by row spacing and direction for the 20 Feb 91 planting date.

Row		Stem Density							
Direction	Row Spacing inches	25Mar	29Mar	03Apr	09Apr	17Apr	26Apr	01May	08May
		----- stems/ft ² -----							
NS	6	8.2	12.4	18.1	25.3	29.7	27.5	27.7	26.3
NS	12	6.8	10.1	13.8	20.8	23.1	22.4	22.1	22.1
NS	18	5.8	8.4	12.2	16.7	18.0	19.0	18.9	18.2
NS	24	4.5	6.8	9.0	13.9	16.1	16.8	17.1	16.1
EW	6	8.8	12.1	18.3	24.3	27.8	28.9	28.3	25.9
EW	12	7.8	10.3	14.3	19.1	21.7	21.3	21.8	21.0
EW	18	6.5	8.8	12.0	16.2	18.8	20.8	19.5	18.3
EW	24	6.6	8.3	11.4	16.2	18.5	18.4	18.1	17.7
--	6	8.5	12.3	18.2	24.8	28.7	28.2	28.0	26.1
--	12	7.3	10.2	14.0	20.0	22.4	21.8	21.9	21.6
--	18	6.1	8.6	12.1	16.4	18.4	19.9	19.2	18.2
--	24	5.6	7.5	10.2	15.1	17.3	17.6	17.6	16.9
NS	--	6.3	9.4	13.3	19.2	21.7	21.4	21.5	20.7
EW	--	7.4	9.8	14.0	18.9	21.7	22.3	21.9	20.7
Spacing		**	**	**	**	**	**	**	**
Direction		**	NS	NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS	NS	NS

Table 3c. Stem density over time as influenced by row spacing and direction for the 20 Nov 91 planting date.

Row Direct- ion	Row Spacing	Stem Density										
		10Dec	16Dec	23Dec	31Dec	16Jan	23Jan	29Jan	04Feb	18Feb	25Feb	22Apr
		stems/ft ²										
NS	6	8.3	8.3	8.9	17.7	30.3	41.2	50.8	50.8	44.6	46.8	29.8
NS	12	6.9	7.2	8.3	13.8	27.1	37.8	42.3	43.1	39.1	37.9	28.0
NS	18	8.2	8.4	9.0	12.8	22.4	30.6	34.4	35.1	32.6	32.9	25.0
NS	24	7.5	7.0	7.6	12.7	23.2	28.6	35.2	32.7	31.3	31.0	30.8
EW	6	8.7	9.0	9.8	16.1	34.2	46.3	53.9	52.5	47.5	42.1	28.9
EW	12	6.8	6.3	6.6	12.9	26.0	33.1	43.3	42.3	36.3	37.0	29.2
EW	18	9.9	10.3	10.7	15.6	29.7	38.8	43.2	41.5	37.9	38.0	28.8
EW	24	6.9	6.6	8.0	11.6	21.6	29.5	35.0	33.2	30.9	29.1	27.7
--	6	8.5	8.7	9.3	16.9	32.3	43.7	52.3	51.6	46.1	44.4	29.3
--	12	6.8	6.7	7.4	13.3	26.6	35.5	42.8	42.7	37.7	37.4	28.6
--	18	9.1	9.3	9.8	14.2	26.0	34.7	38.8	38.3	35.3	35.5	26.9
--	24	7.2	6.8	7.8	12.1	22.4	29.1	35.1	32.9	31.1	30.1	29.2
NS	--	7.7	7.7	8.4	14.3	25.8	34.6	40.7	40.4	36.9	37.1	28.4
EW	--	7.8	7.9	8.7	13.8	26.7	35.8	41.4	40.8	37.6	36.0	28.2
Spacing		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3d. Stem density over time as influenced by row spacing and direction for the 03 Mar 92 planting date.

Row Direction	Row Spacing	Stem Density						
		23Mar	31Mar	07Apr	14Apr	21Apr	27Apr	27May
		stems/ft ²						
NS	6	4.9	11.2	19.8	27.5	29.0	29.0	24.8
NS	12	4.5	10.7	18.8	24.1	24.3	24.3	21.8
NS	18	3.3	7.0	13.2	15.7	17.0	19.0	20.3
NS	24	6.0	10.6	23.3	24.6	23.8	24.9	21.3
EW	6	5.3	14.5	25.9	32.9	33.6	33.3	27.0
EW	12	4.6	10.8	18.9	23.3	18.6	23.4	19.4
EW	18	4.7	10.7	21.3	20.0	21.7	21.3	24.7
EW	24	7.4	14.5	22.0	23.2	25.6	24.8	21.2
--	6	5.1	12.8	22.8	30.2	31.3	31.2	25.9
--	12	4.5	10.7	18.8	23.7	21.5	23.8	20.6
--	18	4.0	8.8	17.2	17.8	19.3	20.2	22.5
--	24	6.7	12.5	22.7	23.9	24.7	24.9	21.2
NS	--	4.7	9.9	18.8	23.0	23.5	24.3	22.0
EW	--	5.5	12.6	22.0	24.9	24.9	25.7	23.1
Spacing		NS	NS	NS	NS	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS	NS

Table 4a. Light interception at noon at various dates as influenced by row spacing and direction for the 20 Nov 90 planting date.

Direction	Row Spacing inches	Light Interception							
		04Feb	08Feb	13Feb	25Feb	05Mar	27Mar	03Apr	19Apr
		----- % of incident -----							
NS	6	37.6	50.2	56.9	84.8	89.4	92.3	91.6	79.1
NS	12	36.4	50.1	52.1	77.2	84.4	90.9	82.9	86.8
NS	18	27.1	33.1	38.5	72.2	84.3	89.2	84.3	78.6
NS	24	27.1	45.7	49.2	73.0	80.2	85.6	77.6	67.4
EW	6	35.5	44.4	52.2	79.5	90.2	88.6	80.6	72.3
EW	12	28.6	38.3	46.1	83.1	91.1	92.0	93.6	77.5
EW	18	34.4	53.7	57.8	80.4	85.0	89.3	89.4	72.5
EW	24	29.2	33.7	42.8	69.3	83.7	91.0	82.1	78.9
--	6	36.6	47.3	54.6	82.2	89.8	90.5	86.1	75.7
--	12	32.5	44.2	49.1	80.2	87.7	91.5	88.3	82.2
--	18	30.8	43.4	48.1	76.3	84.6	89.3	86.9	75.6
--	24	28.2	39.7	46.0	71.2	82.0	88.3	79.8	73.2
NS	--	32.1	44.8	49.2	76.8	84.6	89.5	84.1	78.0
EW	--	31.9	42.5	49.7	78.1	87.5	90.2	86.4	75.3
Spacing		NS	NS	NS	+	*	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	+	NS	NS	NS	NS	NS	NS

Table 4b. Light interception at noon at various dates as influenced by row spacing and direction for the 20 Feb 91 planting date.

Direction	Row Spacing	Light Interception						
		09Apr	17Apr	26Apr	01May	08May	15May	22May
		----- % of incident -----						
NS	6	17.9	30.4	50.4	49.5	51.4	49.2	43.7
NS	12	16.9	30.3	42.8	48.0	44.3	40.1	42.0
NS	18	9.5	19.9	31.6	34.2	34.0	33.0	31.4
NS	24	13.7	26.4	35.2	34.3	34.6	35.9	31.2
EW	6	24.1	37.9	51.7	53.9	54.5	44.3	44.3
EW	12	16.8	26.1	42.3	43.6	47.1	37.4	34.2
EW	18	14.9	26.5	38.9	40.5	38.7	35.4	36.7
EW	24	12.5	20.6	34.1	34.3	40.8	41.4	33.9
--	6	21.0	34.2	51.0	51.7	53.0	46.7	44.0
--	12	16.8	28.2	42.5	45.8	45.7	38.8	38.1
--	18	12.2	23.2	35.3	37.3	36.3	34.2	34.1
--	24	13.1	23.5	34.7	34.3	37.7	38.7	32.5
NS	--	14.5	26.8	40.0	41.5	41.1	39.6	37.1
EW	--	17.1	27.8	41.7	43.0	45.3	39.6	37.3
Spacing		*	*	**	**	**	**	**
Direction		NS	NS	NS	NS	+	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS	NS

Table 4c. Light interception at noon at various dates as influenced by row spacing and direction for the 20 Nov 91 planting date.

Row Direction	Row Spacing	Light Interception					
		17Jan	23Jan	29Jan	04Feb	18Feb	25Feb
		----- % of incident -----					

NS	6	73.0	85.7	93.1	96.9	99.0	99.6
NS	12	59.9	76.1	83.2	94.2	99.2	99.7
NS	18	54.8	59.3	70.7	82.8	92.4	98.4
NS	24	40.4	50.8	58.0	70.8	98.4	97.1
EW	6	76.7	84.2	94.6	97.2	98.3	99.7
EW	12	64.9	81.2	91.8	96.0	99.2	99.5
EW	18	69.3	82.4	91.8	96.6	99.2	99.5
EW	24	56.9	70.0	81.9	92.5	97.9	98.3
--	6	74.9	85.0	93.9	97.1	98.7	99.6
--	12	62.4	78.7	87.5	95.1	99.2	99.6
--	18	62.1	70.9	81.3	89.7	95.8	99.0
--	24	48.7	60.4	70.0	81.7	98.1	97.7
NS	--	57.0	68.0	76.3	86.2	97.3	98.7
EW	--	58.0	67.6	76.6	86.3	97.1	98.7
Spacing		**	**	**	**	*	+
Direction		**	**	**	**	+	NS
Spac.*Direct.		NS	**	**	**	**	NS

Table 4d. Light interception at noon at various dates as influenced by row spacing and direction for the 03 Mar 92 planting date.

Row Direction	Row Spacing	Light Interception					
		07Apr	14Apr	21Apr	29Apr	05May	15May
		----- % of incident -----					

NS	6	25.2	52.4	67.6	61.0	56.7	53.9
NS	12	29.5	53.4	62.8	60.0	59.9	50.3
NS	18	12.2	36.6	51.2	36.5	47.1	31.6
NS	24	24.7	45.5	51.9	50.3	48.7	44.1
EW	6	31.1	62.5	69.8	64.3	62.5	61.6
EW	12	21.6	50.2	60.3	54.2	54.2	44.9
EW	18	27.6	45.8	43.6	55.8	49.8	48.1
EW	24	23.4	41.6	49.2	45.5	51.1	40.8
--	6	28.1	57.4	68.7	62.6	59.6	57.8
--	12	25.5	51.8	61.5	57.1	57.0	47.6
--	18	19.9	41.2	47.4	46.2	48.4	39.8
--	24	24.0	43.5	50.6	47.9	49.9	42.5
NS	--	22.9	47.0	58.4	52.0	53.1	45.0
EW	--	25.9	50.0	55.7	55.0	54.4	48.9
Spacing		NS	NS	*	NS	NS	NS
Direction		NS	NS	NS	NS	NS	NS
Spac.*Direct.		NS	NS	NS	NS	NS	NS