Yield-Density Responses of Soybean to Light Enrichment

Xiaobing Liu, Stephen J. Herbert, A. Masoud Hashemi, Wen Xu
and Rahman Barzegar
Dept. of Plant and Soil Sciences

Intensity of solar radiation intercepted by the canopy, is an important determinant of yield components and hence the yield of soybean. In previous research, light enrichment using lamps or reflectors increased the yield of soybean, and shading (49-20% of ambient light) resulted in lengthening of internodes and increased lodging in soybean plants. Light intercepted during and after seed initiation growth was shown to be the most sensitive stage of growth, which affects the final grain yield of soybean.

In our previous research light enrichment initiated at late vegetative or early flowering stages increased seed yield by 144% to 252%, while light enrichment beginning at early pod formation resulted in only 32% to 115%. Changes in yield may result from the changes in pod and seed number. However, an increase in seed size may also compensate for a decreased pod load as shown in some source-sink manipulation studies. The effects of light enrichment on seed yield are ultimately reflected through seed size (mass per seed) and/or number of seeds per unit area. However, much of the research conducted previously was either based on a single variety or single density.

Our objectives were to investigate the yield response of different varieties to light enrichment during the early reproductive stage under two densities, and to examine the mechanisms for the yield changes. Light enrichment is not being suggested as a practical way to increase yields but rather is a technique being used to aid the understanding of physiological growth and development.

Seven Roundup Ready (RR) soybean varieties (4 Group I and 3 Group II) were planted on May 16, 2002 at the UMass Agronomy Research Farm in South Deerfield, Massachusetts. All varieties were planted in two densities, 30 plants m^{-2} (low) and 80 plants m^{-2} (high). The experimental design was a complete randomized block design with three replications and each plot consisted of 7 rows 0.25 m apart and 12 m long.

The light enrichment treatment was initiated at the late flower/early pod formation (R_3 stage) by installing 90 cm tall wire mesh fences (mesh hole size 2-3 cm) adjacent to the rows bordering the center sample row, sloping away at a 45° angle from the center row, in each light enriched plot. Fences prevented encroachment of plants from the neighboring rows into the growing space, and thus increased the radiation interception area of the sample row. The fences were inspected periodically (1-3 times a week) and all plants in rows bordering the center were pushed behind the fences to prevent encroachment on the sample row.

Light intensity measurements, using a Licor line quantum sensor (LI-188B) placed parallel to, and beside the center row plants, showed that light intensity after R_3 was always above 25% available light at the base of the canopy for the light enriched treatments. Once put in place at R_3, these fences remained in position until soybean maturity. Plants were harvested beginning on September 28, 2002. Seed yield was determined from 3 m of row in light enriched plots and from the 3 center rows for an area of 2 m^2 for control plots. Seed yield per plant and the yield components for seed number, seed size, and pod number were determined from 15 plants from each plot. Yield of control plots is presented in figure 1.

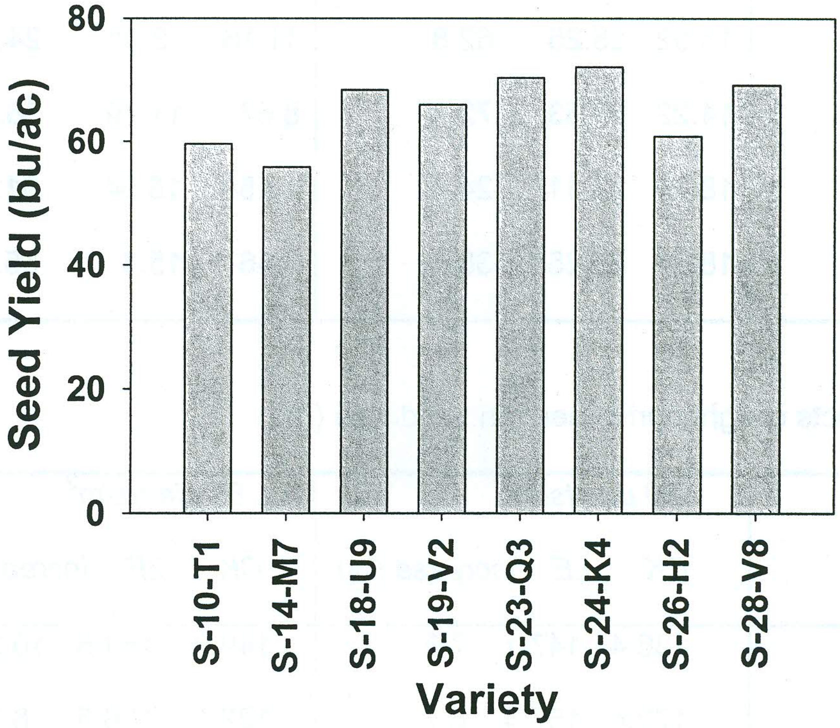

Figure 1. Mean seed yield of 8 RR soybean varieties in 2002(av. of both densities).

Seed yield per plant was significantly increased (17.1% to 72.5 %) with light enrichment (Table 1). As expected, yields at high densities were lower than at low densities, and for some varieties, the yield-increased effect from light enrichment was related to density, with some varieties having more significant increases at high density and some at low. For instance, 62.8% and 72.5% yield gain was obtained in 30 plants/m^2 for varieties S-23-Q3 and S-24-K4, and similar high yield increase was obtained for S-28-V8 at 80 plants/m^2. Generally, the yield increases were due to increases in both seed size and pod number per plant for all densities (Tables 2 and 3).

Table 1. Effects of light enrichment on seed yield per plant (g)

Varieties	*30 plants/m²*			*80 plants/m²*		
	CK	*LE*	*increase (%)*	*CK*	*LE*	*increase (%)*
S-10-T1	16.46	21.86	32.9	7.99	10.73	34.3
S-14-M7	22.53	26.39	17.1	10.32	14.06	36.2
S-18-U9	17.14	23.55	37.4	9.08	11.12	22.5
S-23-Q3	15.52	25.25	62.8	11.16	13.81	24.3
S-24-K4	14.22	24.53	72.5	8.67	11.79	36.0
S-26-H2	18.79	23.41	24.6	12.54	16.54	31.9
S-28-V8	18.24	25.25	38.4	9.46	15.6	65.3

Table 2. Effects of light enrichment on seed size (mg)

Varieties	*30 plants/m²*			*80 plants/m²*		
	CK	*LE*	*increase (%)*	*CK*	*LE*	*increase (%)*
S-10-T1	136.4	147.1	7.8	149.3	164.6	10.2
S-14-M7	172.4	187.4	8.7	182.7	198.3	8.5
S-18-U9	185.9	208.8	12.3	187.2	201.1	7.4
S-23-Q3	152.5	196.2	28.7	174.4	202.8	16.3
S-24-K4	156.8	186.1	18.7	165.1	196.5	19.0
S-26-H2	139.3	164.1	17.8	154.4	173.0	12.0
S-28-V8	149.4	165.1	10.5	154.1	193.3	25.4

Light enrichment had no effect on seed number per pod or on pod number per plant for varieties S-26-H2 and S-14-M7 at low density, but had a significant effect at high density (Table 3). The increase in pod number was likely related to an increase in pod formation from residual flowers at the time of installing the fences for light enrichment, and/or from greater pod retention with a more favorable light environment. Both greater pod number and increased seed size contributed to the increased yield of light enriched plants. In conclusion, seed yield per plant can be significantly increased with light enrichment, and the yield increases were due to increases in both seed size and pod number per plant. The yield-increased effect from light enrichment was related to density, with some varieties having more significant increases at high density and some at low.

Table 3. Effects of light enrichment on pod number per plant

Varieties	*30 plants/m²*			*80 plants/m²*		
	CK	*LE*	*increase (%)*	*CK*	*LE*	*increase (%)*
S-10-T1	49.0	58.8	20.0	22.4	26.4	17.9
S-14-M7	51.0	52.0	1.9	23.1	30.8	33.3
S-18-U9	37.7	46.8	24.1	19.8	24.1	21.8
S-23-Q3	41.0	51.1	24.6	26.1	28.0	7.3
S-24-K4	37.7	51.1	35.4	22.2	24.8	11.7
S-26-H2	60.7	61.8	1.8	35.4	41.1	16.1
S-28-V8	49.7	60.1	20.9	23.7	32.2	36.9