Response of Soybean to Changes in Solar Radiation

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Despite the voluminous research data available on crop yield enhancement by improved interception of solar radiation, the interaction between the solar radiation intercepted and yield components is not yet fully understood. This report summarizes the results of several studies to analyze solar radiation effects on yield components and nodal response of soybean.

Methods

Studies were conducted at the University of Massachusetts Research Farm in Deerfield during 1982-83, 1987-88 and 1994 using indeterminate soybean cultivars 'Altona' of maturity group 00 which matures in approximately 100 days at this location and 'Evans' of maturity group 0 which matures in approximately 115 days. Light enrichment entailed increased solar radiation available to the center row of each plot, which was achieved by installing 90 cm tall wire mesh fencing adjacent to this row sloping away at a 45° angle. Fences prevented encroachment of plants from the neighboring rows into the growing space and thus increased the radiation interception area of the central sample row.

In 1982, treatments were two light levels (light enrichment (LE) at flowering (R_1 stage)), and a control (no light enrichment LE_0. In 1983 and later years, there were three light enrichment treatments (control (LE_0), light enrichment at 5-8 days prior to first flowering (V_5 stage) (LE_1), and at late flower/early pod formation (R_3 stage) (LE_2)). Planting density in these studies was approximately 60 plants/m^2. In 1987-88 and 1994, experiments on Evans were planted at a density of 80-83 plants/m^2.

In all the years, yield was determined by harvesting a sample area from each plot. Yield components were determined from 15 randomly selected plants in each plot.

RESULTS

YIELD/UNIT ROW LENGTH

Seed yield/m of row was significantly affected by light enrichment given at different stages during reproductive growth. Light enrichment at both (R_1 and R_3) stages significantly increased the yield compared to non-enriched plots, the extent of the increase being higher when done at the R_1 stage. For example the two light enrichment treatments in 1983 showed a 144% and 52% increase in yield/plant compared to non-light enriched plots (Table 1). The increase in yield was larger when light enrichment was imposed earlier in the development (at V_5 stage) rather than delaying it to R_1.

Evans responded more to light enrichment than Altona in both years (Table 1). This could be attributed to the greater plasticity of Evans. Evans was a more profusely branching cultivar, exhibited earlier canopy closure compared to Altona thus enabling better exploitation of available light. This was among the reasons why in later experiments we used only the Evans.

YIELD COMPONENT ANALYSIS

Pods per plant

The analysis of the yield components from all the years revealed that pod number per plant was the component most responsible for yield increase from light enrichment. This varied from a 51.6 % increase in the number of total pods for Evans in 1982, with no significant changes for Altona. In 1983, higher yield in both LE_1 and LE_2, were mainly caused by increase in pod number per plant, although increases in seeds per pod and seed size were also responsible, to a lesser extent. In 1987 and 1988, light enrichment prior to flowering increased the pod number per plant by 60.5 % and 119% of the non-light enriched treatments in 1987 and 1988 respectively. Plants receiving light enrichment beginning at early pod fill (R_3 stage) recorded only about 54% and 60% of the number of pods found in the pre-flower light enrichment (R_l stage) in 1987 and 1988 respectively. Similar results were found in 1994.

Light enrichment imposed during the early reproductive stage of soybean would increase availability of assimilates to the developing seeds, and reduce flower and pod abscission, with a resultant increase in final pod number at harvest.

Seeds per pod

Seed number per pod showed little variation either by cultivar or treatment and was much less affected than pod number per plant by the changes in light regime in these experiments. As evident from these studies, seeds/pod is a minor component influencing the yield change of soybean. There was a small tendency for the seed number per pod to change in response to increased solar radiation levels, with the R_1 stage being the most responsive.

Seed size

In 1982, light enrichment resulted in a 7% increase in average seed size compared to the control. Altona had 17% and 20% heavier seeds than Evans in 1982 and 1983 respectively. In 1983, there was no increase in seed size with light enrichment early in the reproductive period (R_1) compared to control. When light enrichment occurred at early pod fill (R_3), there was a 10% increase in weight per seed. Light enrichment at early pod fill (R_3) significantly increased seed size both in 1987 and 1988. In 1994, seed size exhibited significant increase for both LE_1 and LE_2 over LE_O, with LE_2 having the largest increase.

CONCLUSION

The yield of soybean plant is controlled mostly by pod number per plant, and to a lesser extent by seed size and seed number per pod. These yield components are influenced to varying degrees by changes in the light regime. When light enrichment is done at the R_1 stage, the pod number per plant increases. This is not often accompanied by any increase in seed number per pod or seed size. This may be because, under LE_1 conditions, there was a large increase in the pod number per plant and the assimilates produced between R_1 and R_3 now have to be distributed over a large number of seeds, which leads to a similar seed size. In the LE_2 treatment, pod number per plant did not increase much but the seed size increased compared to LE_1. This may be because added assimilates at this time could only be partitioned toward seed fill since flowering was already complete.

Table 1. Soybean seed yield and seed yield components.

Years		1982		1983	1987	1988	1994
Variety		Altona	Evans	Av. Altona/Evans	Evans	Evans	Evans
Yield meter^{-1}	LE_0	210.0b	212.0b	83.0c	93.0c	63.0c	87.2b
	LE_1	231.1b	351.0a	203.3a	230.0a	178.0a	306.3a
	LE_2	-	-	126.2b	123.0b	90.0b	118.6b
Plants m^{-1} row	LE_0	27.4	26.7	15.0	19.0	21.4	21.0
	LE_1	27.5	27.3	15.0	20.5	21.1	19.6
	LE_2	-	-	15.0	21.2	20.4	17.0
Yield Plant^{-1}	LE_0	7.7b	7.9b	5.5c	4.9c	2.9c	4.2b
	LE_1	8.4b	12.9a	13.6a	11.2a	8.4a	15.6a
	LE_2	-	-	8.4b	5.8b	4.4b	7.0b
Pods Plant^{-1}	LE_0	20.4b	23.9b	12.9b	18.5b	11.5c	11.2b
	LE_1	20.5b	36.2a	30.7a	29.7a	25.2a	34.0a
	LE_2	-	-	16.9b	15.9b	15.2b	15.4b
Seeds Pod^{-1}	LE_0	2.23	2.32	2.26c	2.31	2.13b	2.09b
	LE_1	2.30	2.33	2.39b	2.28	2.28a	2.40a
	LE_2	-	-	2.43a	2.27	2.22ab	2.23ab
Seed Size (mg/seed)	LE_0	168.0b	143.0c	188.0b	180.0b	137.0b	164.7b
	LE_1	177.0a	153.0c	188.0b	172.0b	143.0ab	191.5a
	LE_2	-	-	206.0a	194.0a	148.0a	203.0a