All pairs appear to have similar agronomic characters and disease reactions as those of the recurrent parent. Hence, NC-PMS and NC-PMR are resistant to Race 1 of Heterodera glycines, the soybean cyst nematode, as is Pickett 71. Since resistance to bean pod mottle virus has not been identified in the soybean germplasm, mosaic-resistant cultivars would not sustain the synergistic yield losses caused by double infection of pod mottle virus and mosaic virus (Ross, 1968, 1969b). Approximately 100 seed of each line may be obtained from J. P. Ross upon request.

References

Kiihl, R. A. S. 1976. Inheritance studies of two characteristics in soybeans (Glycine max [L.] Merrill): I Resistance to soybean mosaic virus; II Late flowering under short-day conditions. Ph.D. Thesis, Mississippi State Univ., Mississippi State, MS.

Ross, J. P. 1968. Effect of single and double infections of soybean mosaic and bean pod mottle viruses on soybean yield and seed characters. Plant Dis. Rep. 52: 344-348.

Ross, J. P. 1969a. Pathogenic variation among isolates of soybean mosaic virus. Phytopathology 59: 829-832.

Ross, J. P. 1969b. Effect of time and sequence of inoculation of soybeans with soybean mosaic and bean pod mottle viruses on yield and seed quality. Phytopathology 59: 1404-1408.

Ross, J. P. 1977. Effect of aphid-transmitted soybean mosaic virus on yields of closely related resistant and susceptible soybean lines. Crop Sci. 17: 869-872.

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1) Effects of light on soybean leaf chlorophyll content--The role of the Y_{11} gene.

Previous studies on the genetics of chlorophyll production have revealed the involvement of a gene Y_{11}, which is incompletely dominant. Thus, three phenotypes may be observed--plants with leaves that are normally pigmented, light-green or yellow. The yellow is a lethal in nature; however, we have propagated them under laboratory conditions either by grafting the yellows to wild-type plants or growing them independently under constant low-level illumination with a short period of moderate (400 ft-c) illumination each day. Under the low light conditions, the presence of considerable chlorophyll is evident in the leaves of these yellow plants (Noble et al., 1977). Such plants are capable of sufficient CO_2 fixation to survive and grow at a reduced rate.

Variations of the light environment have revealed that the chlorophyll content of the light-green phenotype can be increased by 100% but this same lighting condition increases the chlorophyll content of dark-greens by less than 20%. Furthermore, chlorophyll content of yellows can be elevated 900%.

From the data in Table 1, it is seen that yellow plants can be grown with chlorophyll levels as high as those for light-greens grown under normal conditions. Visual distinction between the two cannot be made on the basis of leaf color, but can be made on the basis of plant vigor. Visual distinction between dark-green plants grown under high light and light-green plants grown under low light is not usually possible.

We first noted the effects of light intensity on chlorophyll content of leaves in 1972 when our first grafting studies were done; however, such effects were not reported in the literature until later. Koller and Dilley (1974) reported increases in chlorophyll content in the light-green with decreasing light intensity. They did not approach a condition where the light-green plant had chlorophyll levels as high as those in dark-green plants.

These observations point to the likelihood that the $\underline{Y_{11}}$ gene is not directly involved in the biochemical pathway leading to chlorophyll synthesis. Instead it appears to be involved either in the regulation of the amount of chlorophyll synthesized or the regulation of the rate of degradation of chlorophyll following synthesis.

Table 1

Chlorophyll content (mg per gram fresh weight) of three phenotypes vs. light intensity

	Dark-green		Light-green		Lethal yellow	
	High light intensity	Low light intensity	High light intensity	Low light intensity	High light intensity*	Low light intensity
Chlorophyll	2.04	2.38	.6	1.45	.09	.62
Number plants	9	5	5	5	7	7

*Grafted.

References

Koller, H. R. and R. A. Dilley. 1974. Light intensity during leaf growth affects chlorophyll concentration and CO_2 assimilation of a soybean chlorophyll mutant. Crop Sci. 14: 779-782.

Noble, R. D., C. D. Czarnota and J. J. Cappy. 1977. Morphological and physiological characteristics of an achlorophyllous mutant soybean variety sustained to maturation via grafting. Am. J. Bot. 64(8): 1042-1045.

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2) Photosynthetic activity in chlorophyll deficient soybean leaves carrying the Y_{11} mutant.

In soybeans, the Y_{11} gene is involved in chlorophyll synthesis. Thus, in the heterozygous condition $Y_{11}y_{11}$, an intermediate or light-green leaf pigmentation results. Photosynthetic CO_2 assimilation in the light-green, on a surface area basis, has been reported to be as high or nearly as high as in the homozygous dominant, dark-green plant (Wolf, 1965; Keck et al., 1974; Cappy and Noble, 1974; Crang and Noble, 1978). When photosynthesis is expressed on a chlorophyll basis, the rates for light-green plants are quite impressive. Koller and Dilley (1974) report photosynthesis to be four times greater in light-green than in dark-green plants, when expressed on a chlorophyll basis.

Such observations led Stiehl and Witt (1969) and Keck et al. (1970) to the hypothesis that the light-green phenotype might possess a more efficient energy trapping system. They went to the rate limiting step in the electron transport system and were able to show a substantially faster rate of oxidation of plastiquinone in pigment systems from light-green leaves. These observations seemed to confirm the notion that the efficiency of the photosynthetic system of the light-green was greater than that of the dark-green phenotype.

Our own observations reveal that photosynthesis in the light-green plant is three to four times faster than in the dark-green (on a chlorophyll basis); however, when expressed on a surface area basis, the rate of CO_2 uptake in the light-green was 15-20% lower. These measurements were made on plants grown at 2500 ft-c. In an attempt to test the photosynthetic efficiency of the light-green plants further, they were grown under continuous incandescent illumination, at 60 ft-c, with a supplemental four-hour period of fluorescent illumination at 400 ft-c.

Under these conditions, the chlorophyll content of the light-green plants rose from 0.6 mg (on a gram fresh weight basis) to 1.45 mg, and an inverse photosynthetic relationship was observed. When light-green plants from low light and high light conditions were compared on a chlorophyll basis, the photosynthetic rate dropped from 15.4 mg CO_2 to 9.2 mg CO_2 while, on a surface area basis, the photosynthetic rate remained unchanged. If one uses the photosynthetic rates based on chlorophyll for the light-green phenotype to predict the photosynthetic rate for a dark-green whose chlorophyll content is known, the predicted and measured values coincide very closely. This suggests that the chlorophyll is functioning in a similar manner in both phenotypes.

From these observations, it appears that the amount of chlorophyll in the light-green phenotype is usually sufficiently high that it does not limit photosynthesis. Elevation of chlorophyll content, while not affecting net CO_2 assimilation, results in lower efficiency when calculated on a per chlorophyll basis. Therefore, photosynthetic comparisons often made between the light-green and dark-green phenotypes may be misleading when made on this basis.

References

Cappy, J. C. and R. D. Noble. 1978. Photosynthetic responses of soybeans with genetically altered chlorophyll. Ohio Acad. Sci. 78: 267-271.

Crang, R. E. and R. D. Noble. 1974. Ultrastructural and physiological differences in soybeans with genetically altered levels of photosynthetic pigments. Am. J. Bot. 61(8): 903-908.

Keck, R. W., R. A. Dilley and B. Ke. 1970. Photochemical characteristics of a soybean mutant. Plant Physiol. 46: 699-704.

Koller, H. R. and R. A. Dilley. 1974. Light intensity during leaf growth affects chlorophyll concentration and CO_2 assimilation of a soybean chlorophyll mutant. Crop Sci. 14: 779-782.

Stiehl, H. H. and H. T. Witt. 1969. Quantitative treatment of the function of plastiquinone in photosynthesis. Z. Naturforsch. 24b: 1588-1598.

Wolf, F. T. 1965. Photosynthesis of certain soybean mutants. Bull. Torrey Bot. Club 92: 99-101.

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1) A breeding project aimed at producing major morphological changes required to fit a soybean "idiotype".

There is evidence that only small increases in yield have resulted from soybean breeding in the United States during the past 30 years and that some major limitations to yield have been reached (Frey, 1971). During this period the main advances have been in developing resistance to pests and diseases, and improving agronomic traits such as resistance to lodging and shattering.

Considerable increases in yield have been achieved during this period in programs conducted for the development of soybeans in the tropics and subtropics through adaptability to short days and high temperatures. These yield improvements are analogous to those obtained in the U.S.A. some decades ago when comparable advances were made. It can therefore be expected that yield improvement will decline once certain levels have been reached.

What factors limit yield? The physiological limitations to yield which have been reached probably relate to both the carbon and nitrogen metabolism of the crop. It is necessary to examine some information relevant to these limitations before considering how they may be overcome.

Carbon assimilation as a limitation of yield: The photosynthetic apparatus of this crop is not remarkable for its efficiency, and in the opinion of many researchers in this field, there is little prospect of large yield improvements (Duncan, personal communication). The plant has a C_3 metabolic pathway and therefore individual leaves become light saturated at relatively low light intensities. While there are variations in photosynthetic rate between varieties (Dornhoff and Shibles, 1970; and Shibles, personal communication), the relationship between yield and photosynthetic capabilities is apparently not great.

It would seem, therefore, that the problem of photosynthate supply may best be overcome by spreading the available light at a lesser flux density