High Soybean Yield Can Mean Higher Concentrations of Isoflavones

By Xinhua Yin and Tony J. Vyn

Across a range of studies involving tillage, row width, and potassium (K), the higher soybean yield levels were associated with markedly higher isoflavone concentrations...but with little change in oil and protein. Part of the increase of isoflavones with seed yield may have resulted from a parallel increase of seed K concentrations.

Soybeans are traditionally produced for the oil and protein in the seed, which are the economically important quality components of the crop. Seed of current U.S. soybean cultivars contains on average approximately 41% protein and 21% oil on a dry weight basis (Hartwig and Kilen, 1991). Another component that may someday gain economic value is the content of isoflavones, because of their positive potential role in prevention of cancer, heart disease, osteoporosis, and menopausal symptoms (Caragay, 1992; Hasler, 1998).

Our objective was to determine the relationships of the concentrations of isoflavones, oil, and protein with seed yield of soybean across a wide variety of production environments.

We conducted investigations at five sites in Ontario from 1998 through 2000. Each site had a history of at least 5 years of continuous no-till. Soil test K levels in the 0 to 6 in. depth ranged from low…35 parts per million (ppm)…to very high (155 ppm). Treatments included both rates and placement (broadcast vs. banded) of K fertilizer at all sites, and fall disk tillage to a depth of 4 in. as a variable at two of the sites. All remaining treatments were grown with no tillage. The investigations involved a total of four varieties. For further details, see Yin and Vyn (2005).

Yield-promoting factors, while slightly reducing oil, can boost levels of isoflavones in soybean seeds.

We grouped the results into four yield categories: low (<37 bu/A), medium (37 to 45 bu/A), high (45 to 52 bu/A), and very high (>52 bu/A). We found that oil concentration differences among the four yield categories were quite small (**Table 1**). For example, oil concentration decreased from 21.7% to 20.8% when yield group increased from low to very high. Protein concentration in seed did not differ significantly among the four yield categories. Isoflavone concentrations, however, increased by almost 50% as yield group increased from low to high.

Table 1. Oil, protein, and total isoflavone concentration of soybeans, grouped according to yield.

Yield group, bu/A	Oil	Protein	Isoflavones, ppm
	------- % -------		
15 to 37	21.7	40.7	1,360
37 to 45	21.5	40.3	1,590
45 to 52	21.0	40.3	2,020
52 to 70	20.8	40.5	2,010

All three types of isoflavones—daidzein, genistein, and glycitein—increased significantly as seed yield increased from the low to the high category (**Table 2**). Daidzein had a greater increase in concentration as soybean yields climbed than either genistein or glycitein. Genistein increased more with yield than glycitein. This suggests that daidzein is the most variable and glycitein is most stable of the isoflavone components. Overall, on a concentration basis, isoflavones varied with soybean yield level to a much greater magnitude than oil and protein.

Soybean seed composition can be affected by cultivars, management practices, and environmental factors. In previous research (Vyn et al., 2002), we observed that K fertilizer application significantly increased soybean seed yield and isoflavone concentrations simultaneously on low-testing K soils; this observation indirectly supports the finding in the current study that individual and total isoflavone concentrations increased as seed yield went up. Our results suggest that high soybean seed yield can be accompanied by high concentrations of isoflavones without any large declines in oil and protein concentrations.

Although linear regression analysis showed that seed oil concentration was negatively and linearly related to seed yield, the decrease was quite small, about 0.3% for a 10 bu/A increase in yield. The relationship between protein concentration and seed yield was not significant. However, concentrations of isoflavones were all positively and linearly related with seed yield. The concentration increases—per ten-bu/A yield increase—amounted to 287 ppm for total isoflavones, 168 ppm for daidzein, 110 ppm for genistein, and 8 ppm for glycitein.

Table 2. Concentrations of the three isoflavone components all increased with yield.

Yield group, bu/A	Daidzein	Genistein	Glycitein
	------------	ppm	------------
15 to 37	580	660	110
37 to 45	680	780	110
45 to 52	960	930	130
52 to 70	970	920	130

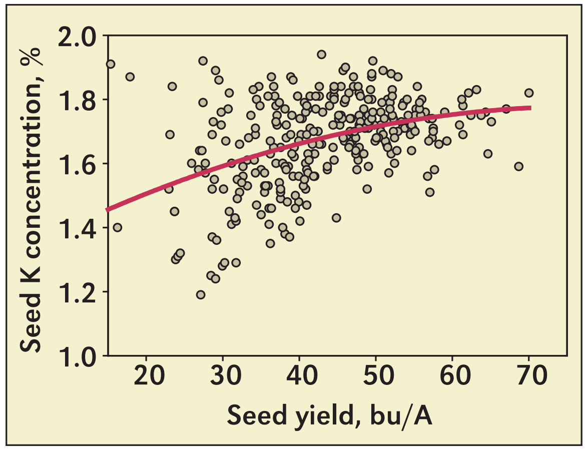

Figure 1. Seed K concentration generally increased with seed yield.

Both K and isoflavone concentrations increased with yield (**Figure 1, Table 1**). Did the increased K cause the increased levels of isoflavones? The answer from our detailed analyses is that K appears only partially responsible.

Multiple-factor linear regression analysis—which included K application and placement, cultivar, location, and growing season as the independent factors—showed that the seed yield differences were not only attributed to the K application and placement effects, but were also attributable to cultivars, locations, and growing seasons. Therefore, the significant relationships of seed quality components with seed yield observed in this study were influenced by more than K application and placement. Several other factors contributing to yield were also associated with increased isoflavones.

In summary, the strong positive relationship of total isoflavone concentration with seed yield and the weak association

Soy foods are becoming more popular for health reasons.

of oil and protein concentrations with seed yield suggests that there was no big trade-off of seed yield or oil and protein concentrations for isoflavone concentration in soybean. Rather, isoflavone concentration significantly increased as seed yield went up, without substantial decreases in oil and protein concentrations. Some of the increase of isoflavones with seed yield may have resulted from a concomitant increase of seed K concentrations with yield.

This positive relationship between total isoflavone concentration and seed yield is very encouraging, as it suggests that high soybean yield could be compatible with high quality from an isoflavone-based functional food perspective. Furthermore, high total isoflavone concentration in seed can be achieved without large decreases in oil and protein concentrations. BC

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