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Continuing Education Self-Study Course

# potential of value-add CULTIV

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The south central U.S. region has been particularly affected by the decline in tobacco (*Nicotiana tabaccum* L.) production. With the loss of a critical crop, there is a need to explore alternatives. Of particular interest are commodities that are familiar to growers and can be grown with farm equipment readily available to farm operators in the region. High-protein and tofu soybean cultivars both have high protein concentrations and are considered value-added crops. These specialty soybean cultivars may offer better economic returns than growing commodity soybean, depending on production potential and cost of crop management of these value-added crops in this region.

Although soybean production for the food industry accounts for a small fraction of the national soybean market, this market is a highly profitable niche. Furthermore, the soyfood industry is growing at a faster rate than the commodity soybean sector. The premiums for food-grade soybean are in the range of \$74 $Mg^{-1}$ (about \$2.00/bu), although the best prices are available for certified organically grown food-grade soybean. High protein concentration is an important quality component of many soyfoods. Consequently, not only is high-protein soybean likely to increase in importance, but food-grade soybean is also likely to gain as an important niche market. Production of high protein and tofu soybean cultivars has the potential to significantly improve returns.

However, little is known of the management practices required or the production potential of novel soybean cultivars in the south central U.S. The production potential of tofu and high protein soybean may be lower than standard soybean cultivars since seed protein concentration is usually negatively correlated with seed yields. High protein cultivars are considered to yield considerably less than conventional cultivars of similar maturity.

The relationship between yield and protein concentration has led to speculation that N stress may limit seed yield. There have been conflicting reports on the advantages of late season N application to improve soybean yield and possibly protein concentration. More plant N may arise from access to more soil-available N or through increased duration or rate of $N_2$ fixation. In discussing the relationship between C and N assimilation and yield, it was concluded that crop productivity is ultimately dependent on adequate N supply and at the appropriate stage of development. Although there is a genetic component to yield, some have suggested that the large impact of environment on yield was due to the availability of N supply. If this is indeed the case, the need for N would be even greater in genotypes with high seed protein such as the tofu and the high protein soybean cultivars. The yield of the high-protein and tofu cultivars may therefore be responsive to late season N application by reducing the impact of N limitation stress on soybean yield.

Because the tofu genotypes tested were developed in states to the north and west of the present test sites, it is not known how well these cultivars would be adapted to different regions of central and western Kentucky, which represents the south-central region of the U.S. Soil and climatic differences may have implications not only for production potential but also for appropriate management practices. Considering the longer growing season in the south central region, it may be possible to plant at lower densities because we have a longer period over which canopy cover may be established. Lower plant densities could have the added benefit of increasing seed size, a desirable quality for food-grade soybean. Lowering plant density has the added advantage of providing savings on the cost of seed. Late season N fertilizer application may also maintain the higher protein concentration in these cultivars and still allow for high yields.

There is only limited information available on either novel soybean cultivar performance in the south central region, or the optimum management practices required to grow food-grade and high-protein soybean cultivars in this region. The objectives of this research were: (i) to determine the production potential of novel soybean cultivars in the south central region, and (ii) to evaluate management strategies for novel soybean production in this area.

## TOFU EXPERIMENT

The experiment was conducted in Lexington, Ky., and Princeton, Ky., in 2000 and 2001. The field plots in Lexington were located on the Spindletop research station (38° N lat, 84° W long) and the soil at this location was a Maury silt loam (fine, mixed, semiactive, mesic Typic Paleudalfs). The field plots in Princeton were at the Princeton research station (37° N lat, 87° W long) and the soil at this location was Crider silt loam (fine-silty, mixed, active, mesic Typic Paleudalfs).

The treatments consisted of four cultivars, two plant densities and two N treatments. The cultivars selected consisted of three tofu-type soybean and one commodity-type soybean. Cultivar 'FG1' (Ohio Foundation Seed) was selected as it had a popular market position in the Japanese market. Cultivar 'IA3011' (Iowa State University) was ed soybean

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## Management and production potential of value-added soybean cultivars in South Central United States

Photo courtesy of ARS

the highest yielding among the maturity group (MG) III lines from the Iowa State University cultivar release program. Pioneer brand '9305' (Pioneer Hi-Bred International, Johnston, Iowa) was selected as representative of a private company release. The commodity check soybean cultivar was Pioneer brand '93B01.' It was selected as a representative of a high-yielding commodity soybean cultivar against which the three food-grade cultivars were tested.

### HIGH-PROTEIN EXPERIMENT

This experiment was conducted in 2000 and 2001 and at the same two locations as the previous experiment. The precipitation and daily average temperature data were obtained from two nearby weather stations (<1.5 km, or < 1 mile from each of the field plots).

The treatments consisted of six cultivars and two N treatments. Six genotypes with high and standard protein concentrations in MG II, III, and IV were selected. Data from uniform regional tests were used to select high-protein cultivars that also had good yield potential. The standard commodity cultivars were selected using results of Kentucky Soybean Performance Tests. The high-protein MG II genotype 'U97-207427' (University of Nebraska) was paired with the standard protein cultivar 'Jack' (Illinois Foundation Seed). The high-protein MG III cultivar 'NE 3396' (University of Nebraska) was paired with the standard protein cultivar '93B11' (Pioneer Hi-Bred International). The high-protein MG IV cultivar 'KS4103sp' (Kansas State University) was paired with the standard protein cultivar Caverndale 'CF461' (Caverndale Farms, Danville, Ky.).

The experimental design and statistical procedures were similar for all experiments reported. The experiments were designed as randomized complete block designs with four replications at each location. The experimental data were analyzed using Proc GLM, with years, locations, and blocks being random and blocks nested within years and locations.

### TOFU TEST RESULTS

The yield of tofu and conventional soybean cultivars was affected by year, location and cultivar. Across cultivars and years, the mean yield was higher at Spindletop than at Princeton. No relationship was apparent between the precipitation received and the yield levels at the four location/years. There was, however, a relationship between temperature and yield at the two locations. Princeton is in a more southern location and the average growing season temperatures are several degrees above that for Spindletop. It was postulated that the higher growing temperatures accelerated the rate of development of the plants grown at Princeton. The consequent shorter growing period, and therefore, the shorter period of assimilate accumulation at Princeton may well have led to the lower observed yields. Considering that these tofu cultivars were developed in more northern regions and are MG III cultivars, their sensitivity to higher temperatures is not unexpected. Cultivars better adapted to the warmer weather could potentially yield more.

There was a significant impact of seeding density on yield. Yield was higher (4.47 Mg ha$^{-1}$, or 66 bu/A) under 100 percent of the traditional seeding rate than under 67 percent of the traditional seed rate (yield of 4.31 Mg ha$^{-1}$, or 64 bu/A). However, with only the two plant densities tested, it does not offer us an opportunity to determine the optimal plant density for the novel soybean cultivars used in this test. Further tests are required with a larger range of plant densities to determine the optimum plant density of these cultivars. There was a year x density interaction for seed size. In 2001, the impact of higher plant density on yield was due to a significant increase in seed size. In 2000, there was no impact of higher plant density on seed size so the yield increase that year was related to a significant increase in seed number. It was expected that low plant density would produce larger seeds because of lower plant-to-plant competition and consequently more resources per seed set. Although the relationship between plant density and seed size in 2001 was unexpected, others have also observed this relationship. The current study illustrated that the traditional plant density used for commodity soybean production would not only produce good yields of value-added soybean cultivars, but will not adversely impact the large seed size of these cultivars.

There was a significant cultivar effect on protein and oil. There were significant cultivar, location and year effects on seed size. Consistent with what is expected of a tofu-type soybean, the tofu cultivars were larger-seeded (seed size of 93B01 was 121 mg seed$^{-1}$ vs. 199 mg seed$^{-1}$ for the average of the three tofu cultivars) and had higher protein concentrations and lower oil concentrations than the commodity cultivar to which they were compared. Based on the results of this study, it was apparent that the food-grade soybean cultivars from MG III have as good a yield potential in this region as the high yielding, MG III check.

Consistent with previous reports, in the current study, application of fertilizer N had no significant impact on yield or protein concentration. Also, there was no significant interaction of planting density and N fertilizer treatment on seed yield or protein concentration. The results of the current study support the contention that management strategies, specifically the plant density and fertility management currently used in commodity soybean production, is satisfactory to obtain comparable seed yield, and comparable or higher protein concentrations in tofu soybean.

## HIGH PROTEIN TEST RESULTS

Yield and yield components (seed size and seed number) of the six genotypes tested were affected by location, year and genotype. The plots at Spindletop had higher yields than those at Princeton in both years of the test. The warmer temperatures in Princeton may have accelerated the rate of development, and thus hastened maturity and resulted in reduced yield potential. The fact that even the later maturity group (MG IV) cultivars from both high protein and standard cultivars maintained higher yields at Spindletop may be an indication that the yield potential of even later maturing cultivars were limited by the higher temperatures in Princeton. The data from multi-year, state-wide, variety tests also indicated that the yield potential in Princeton is lower than that at Spindletop for MG III and IV cultivars.

Of the six cultivars tested in MGs II, III, and IV over four location/years, no trend in higher yields with later MG cultivars was observed in either the normal or the high protein lines. This is consistent with a previous study by Egli, who also reported that there was no relationship between MG and seed yield in a two-year study of four soybean cultivars from MG 00 to V grown in Kentucky. Egli contends that the reproductive period is the most critical for yield determination, and that the longer vegetative growth period of later-maturing cultivars does nothing to improve seed yield. The significance of the reproductive period for yield has been reported by a number of researchers. Because changes in MG do not alter the duration of the reproductive period, yield of cultivars from different MGs grown in this region is more likely dependent on environmental conditions during the reproductive period than on the length of the growing period per se (i.e., MG).

Although in the high-protein test there was no significant genotype main effect on yield, there was a significant genotype main effect on seed quality. Consistent with previous studies that contend that seed protein and oil concentrations are genotype-dependent, the genotypes in this study also showed consistency in protein and oil concentrations across years and environments. The high protein genotypes had significantly higher protein concentrations and lower oil concentrations than the normal cultivars against which they were compared.

It is generally considered difficult to produce high-yielding, high-protein cultivars due to the negative relationship between seed protein concentration and seed yield. In the current study, only one of the three high protein cultivars tested showed a negative correlation between seed yield and seed protein concentration. The cultivar KS4103SP (a high-protein MG IV cultivar) had at least 20 percent greater protein concentration than its check, the highest protein concentration of any of the cultivars tested, and yielded consistently lower than its regular protein counterpart. The yields of the other two high protein cultivars tested were not consistently lower, and in some cases were even higher than the yield of the regular protein cultivars against which they were tested.

As was observed in the tofu-grade soybean test, in the high-protein test, there was no consistent relationship between late season N fertilizer application and yield or protein concentration. Furthermore, the greater protein concentration was apparent whether or not they received late-season N fertilizer application. It is therefore concluded that late-season fertilizer N application is not necessary to maintain high protein concentrations or to improve seed yield of high protein soybean genotypes.

## SUMMARY

There was good production potential for value-added soybean cultivars in the south central region of the U.S. as long as the plants were harvested in a timely fashion to avoid early shattering, a common problem with many high protein and tofu-grade soybean cultivars. Both high protein and tofu-grade soybean had comparable yields and generally greater protein concentrations and frequently larger seed size (tofu-grade soybean) than an equivalent standard commodity soybean. The value-added soybean cultivars responded well to current management practices used to grow regular commodity soybean cultivars. Neither change in plant population density or late-season fertilizer applications was necessary to maintain good yield and quality. Therefore, production of value-added soybean cultivars in this region appears to be a valid option for producers interested in alternative crops.

DETACH HERE

# Management and production potential of value-added soybean cultivars in South Central United States

## May Self-Study Examination

**1. A characteristic of soybean production for the food industry includes all of the following EXCEPT that it**
[ ] a. can be highly profitable for growers.
[ ] b. is a segment that is growing more slowly than commodity soybeans.
[ ] c. offers the best prices for certified food grade organic.
[ ] d. is a small part of the current soybean production market.

**2. A factor associated with increased soybean seed protein is**
[ ] a. adequate in-season nitrogen availability.
[ ] b. low planting rates.
[ ] c. limited manure applications.
[ ] d. using higher rates of glyphosate.

**3. In past studies, the yield of high protein soybean varieties as compared to conventional soybeans is usually**
[ ] a. slightly more.
[ ] b. similar.
[ ] c. slightly less.
[ ] d. considerably less.

**4. An objective of this research was to**
[ ] a. evaluate management strategies for novel soybean production.
[ ] b. determine the environmental impact of soybean production in the south central U.S.
[ ] c. assess weed control and fertility options for organic production.
[ ] d. test marketing opportunities of high protein and tofu soybeans.

**5. A characteristic of the tofu experiment component of this research was that it included**
[ ] a. additional locations in Iowa and Ohio.
[ ] b. a site with heavy clay soils.
[ ] c. a commodity soybean variety.
[ ] d. two times of nitrogen applications.

**6. A factor that led to lower yields at one of the study locations was**
[ ] a. higher temperatures that shortened the reproductive period.
[ ] b. differences in rainfall.
[ ] c. pressure from soybean cyst nematode.
[ ] d. difficulty in combining the larger-seeded varieties.

**7. A characteristic of the high protein soybean varieties in this study was their**
[ ] a. reduced protein quality.
[ ] b. lower oil concentrations.
[ ] c. higher fiber content.
[ ] d. poor seed quality.

**8. A reason why lower plant densities could produce larger seeds is**
[ ] a. more resources per seed set.
[ ] b. greater branching.
[ ] c. reduced light infiltration into the canopy.
[ ] d. lessened risk for foliar diseases.

**9. In both the high protein and tofu tests, late season nitrogen applications**
[ ] a. increased seed protein levels.
[ ] b. increased soybean yields.
[ ] c. decreased seed size.
[ ] d. did not affect seed protein.

**10. Value-added soybean cultivars in the south central region of the United States would be a valid option for producers who**
[ ] a. are struggling to produce acceptable yields of conventional soybean varieties.
[ ] b. are looking for an alternative crop for which they can negotiate a higher price.
[ ] c. process their soybeans for their livestock.
[ ] d. use soybeans as a double-crop after winter wheat.

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**Rating Scale: 1=Poor 5=Excellent**

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This article addressed the stated competency area and performance objective(s): 1 2 3 4 5

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