Growth and Yield of Vegetable Soybean (Edamame) in Mississippi

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ADDITIONAL INDEX WORDS. edible soybean, maturity group, net returns

SUMMARY. Soybean (*Glycine max*) grown as a vegetable is gaining in popularity in the U.S. and demand is expected to increase over the long term. However, information on production in the U.S. is limited because most of the product is imported. Field experiments were conducted at Stoneville, Miss., in 2004 and 2005 to evaluate the production and yield potential and to estimate the net returns for sustainable production in the Mississippi Delta. In 2004, four vegetable soybean varieties were evaluated and 23 varieties were evaluated in 2005. The varieties varied from maturity group III to VII. The late-maturing varieties were generally taller, had more nodes/plant, pods/plant, and fresh green pod yield at R6 stage (full seed) than the early-maturing varieties. Fresh green bean yield ranged from 1438 to 19,119 lb/acre in 2004. The mean bean yield for the 18 Apr. 2005 planting was 26,538 lb/acre compared with a mean of 18,131 lb/acre for the 10 May 2005 planting. Interaction occurred between planting date and variety as well as soil type and variety for all the variables evaluated. 'Envy' produced the lowest yield, whereas 'Garden Soy 01', 'Garden Soy 21', 'Midori Giant', 'Mojo Green', and 'Moon Cake' produced the highest fresh bean yield. The estimated net returns, using the Mississippi State Budget Generator as a guide, indicated more than twice the returns from growing the regular commodity soybean. The data suggest that vegetable soybean can fit well into the existing cropping system and could be a viable alternative crop for growers in the Mississippi Delta who want to capitalize on a niche market.

Vegetable soybean, also called edamame, is becoming increasingly popular in the U.S. as a result of the high nutritional value and health benefits. These soybeans are harvested when the pods are fully filled and still green. Fresh or frozen vegetable soybeans are eaten just like green peas (*Pisum sativum*). The pods are boiled and the beans added to stews, mixed vegetables, soups, stir-fried vegetables, and so on. They are very popular in Asian countries, including China (Guan, 1977), Japan (Benziger and Shanmugasundaram, 1995), and Korea (Hong et al., 1984). National consumption in Japan averaged 159,900 tons annually (Nguyen, 1997) and demand in the U.S. is estimated to be 14,877 tons per year by 2010 (Johnson, 2000).

Vegetable soybeans differ from regular soybeans in many ways. They are usually large-seeded with mild taste, tender, and easily digestible. Fresh green soybeans also have a com-

bination of low oil and relatively high protein content (Brar and Carter, 1993). They also contain a lower percentage of gas-producing starches. Harvesting vegetable soybeans at the right time is critical for maximum texture and flavor (Johnson, 2000; Wszelaki et al., 2005), because loss of quality occurs when pods turn yellow. Beans reach their maximum sweetness $\approx$ 1 month after flowering. The quality is best when the pod is plump and bright green, similar to snow peas (*P. sativum*) in color.

Soybean breeders in the U.S. have crossed some of the large-seeded Asian varieties with adapted U.S. grain varieties and have developed several varieties that are better adapted to the growing conditions in the U.S. A number of promising vegetable-type soybean lines adapted to various growing conditions have been se-

lected by scientists from several state universities in Illinois, Ohio, Washington, Virginia, Arkansas, etc., as well as from the USDA. Scientific information on vegetable soybean production is very limited, especially in the midsouthern U.S., although potential advantages for growing exist. These advantages include: 1) vegetable soybeans in the midsouthern U.S. can be planted early to take advantage of early market opportunities and longer marketing season; 2) some vegetable soybeans can reach R6 stage (full seed and still green) (Fehr and Caviness, 1977) before late July or early August when drought stress normally occurs and thus avoid drought stress; and 3) there are many small soybean farmers in the midsouthern U.S. who can easily adopt vegetable soybean production and may be able to find a niche market for this high-value alternative crop. The objectives of this study were to evaluate the adaptation and yield potential of vegetable soybeans and to determine viability as an alternative crop in Mississippi.

Materials and methods

Field experiments were conducted at the Delta Research and Extension Center, Stoneville, Miss., on clay loam soil in 2004 and on clay loam (fine, smectitic, thermic Chromic Hapludert) and clay (very fine, smectitic, thermic Chromic Epiaquert) soils in 2005. In 2004, four vegetable soybean varieties, including three commercial varieties ('Besweet 2020', 'Butterbean', and 'Envy') and one USDA variety ('Moon Cake'), were planted on 7 June. In 2005, 23 vegetable soybean varieties were planted on 18 Apr. on clay loam soil and also on clay loam and clay soils on 10 May. Seed sources and varieties planted in 2005 as well as estimated maturity group (MG) based on growth duration in Stoneville are listed in Table 1. Soybean varieties

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Unit

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.3048	ft	m	3.2808
2.54	inch(es)	cm	0.3937
0.4536	lb	kg	2.2046
1.1209	lb/acre	kg·ha ⁻¹	0.8922
(°F - 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

Table 1. Vegetable soybean varieties, seed sources, and the estimated maturity groups (MG) range used for the 2005 experiments in Stoneville, Miss.

Variety	Source ^z	Planting date		Estimated MG range ^y
		18 Apr.	10 May	
Bellesoy	Wannamaker	Yes	Yes	>VII
Besweet 2020	Vermont	Yes	Yes	L-III – E-IV
Butter Bean	Johnny's	Yes	Yes	L-III – E-IV
Envy	Johnny's	Yes	Yes	<III
Green Lion	Wannamaker	Yes	Yes	>VII
Garden Soy 01	UI	Yes	No	E-IV
Garden Soy 11	UI	No	Yes	L-III – E-IV
Garden Soy 21	UI	Yes	Yes	L-IV
Garden Soy 22	UI	No	Yes	L-IV
Garden Soy 24	UI	Yes	No	L-III – E-IV
Garden Soy 31	UI	Yes	Yes	E-IV
Garden Soy 41	UI	Yes	No	L-III – E-IV
Garden Soy 42	UI	Yes	No	L-III
IA2025	Cooper	No	Yes	L-III – E-IV
Midori Giant	Wannamaker	Yes	Yes	L-III – E-IV
Mojo Green	Wannamaker	Yes	Yes	L-V – E-VI
Moon Cake	USDA/ARS	Yes	Yes	L-V – E-VI
WSU-618	Washington State	No	Yes	E-IV
WSU-706	Washington State	No	Yes	L-III
WSU-710A	Washington State	Yes	Yes	E-IV
WSU-729	Washington State	No	Yes	E-V
WSU-730A	Washington State	Yes	Yes	L-III – E-IV
WSU-743	Washington State	Yes	Yes	E-IV

^zCooper = Cooper Seeds, Lawrenceville, Ga.; Johnny's = Johnny's Selected Seeds, Winslow, Maine; UI = University of Illinois, Urbana-Champaign; USDA/ARS = U.S. Department of Agriculture/Agriculture Research Service, Beltsville, Md.; Vermont = Vermont Bean Seed Co., Randolph, Wis.; Wannamaker = Wannamaker Seeds, Inc., St. Matthews, S.C.; Washington State = Washington State University, Pullman.

^yL = late, E = early.

have been classified into 13 MGs expressed as Roman numerals. The MG 000 varieties are the earliest in maturity and MG X varieties are the latest. The experimental design for both years was a randomized complete block with four replications. Each plot consisted of four 20-ft-long rows planted on 20-inch spacing at a seeding rate of six seeds per foot. The seeding rate was based on results from previous studies using regular soybean at the same location (unpublished data). The emergence, growth, and development as well as disease incidence were monitored throughout the growth period. The fields were irrigated three times (1 inch of water at each irrigation) during June and July through an overhead lateral move system. Weeds were controlled using field cultivation and hand weeding. Date of emergence and dates reaching individual phenologic growth stages, specifically flowering (R1), full seed (R6), and physiological maturity (R8) (Fehr and Caviness, 1977), were recorded. Plants were hand-harvested at R6 stage from one-half of each plot (i.e., from two center

rows) and the other half left to reach full maturity to determine the entire growth duration and maturity group of individual varieties. Other variables recorded at R6 stage include plant height (measured from the soil level to the tip of the stem), number of nodes, number of pods/plant, and number of seeds/pod. The variables were determined from 10 plants randomly sampled from the middle of each plot, and the means were used in the analysis. Data for each experiment were analyzed separately using general linear model procedures of SAS (version 9.1; SAS Institute, Cary, N.C.) because of the differences in the varieties as well as the number of varieties used in the experiments. However, the 2005 data for nine varieties that were planted on both 18 Apr. and 10 May on the clay loam soil were analyzed across planting date. Similarly, data for varieties planted on both clay loam and clay soils on 10 May 2005 were combined. For the analysis combined across planting date on clay loam soil, the planting date, variety, and planting date by variety interaction

were considered fixed. Similarly, soil type, variety, and soil type by variety interaction were fixed factors for the analysis combined across soil type. Blocks were nested either within planting date or soil type and were considered random. Means were separated using Fisher's protected least significant difference (LSD) at 0.05 level of probability.

Results and discussion

Vegetable soybean had similar growth and development characteristics as traditional soybean with growth duration depending on the maturity group. In 2004, varieties 'Besweet 2020', 'Butterbean', and 'Envy' flowered 29 to 34 d after planting (DAP) and reached R6 suitable for harvest as green beans 58 to 64 DAP. The flowering duration was similar to that for the traditional soybean late maturity group (MG) III and early MG IV planted at the same time period (Table 2). 'Moon Cake' took 44 d to reach flowering and 101 d to complete seed fill (R6) and was comparable to the traditional late MG V to early MG VI variety planted at the same period.

Results from the 2005 studies indicated that the estimated MG for the varieties used ranged from groups III through VII (Table 1). Of the 23 varieties evaluated, 16 were considered early varieties. Two varieties, 'Bellesoy' and 'Green Lion', were very late-maturing (later than 'MG VII') and were discarded because they are not suitable for production in the Mississippi Delta. The other late-maturing varieties reached full seed stage (ready for harvest as green beans) 98 to 126 DAP, whereas the early varieties took 70 to 92 d (Tables 3–5). The period from planting to R6 for the early varieties in particular varied between planting dates in 2005. For example, the early varieties reached R6 earlier when planted in April than in May and this could be the result of sensitivity to day length (Cober et al., 1996). Soybean is a short-day plant in which flowering occurs only when the day length is shorter than the critical photoperiod. The plants sown in April were exposed to relatively short days and likely causing early flowering and thus hastening the days to R6 when compared with the May planting date (Zhang et al., 2004). The days to R6 for

Table 2. Plant height, fresh green bean yield and yield components at R6, and estimated maturity group range (MG) of vegetable soybean planted on 7 June 2004 at Stoneville, Miss.^z

Variety	Plant ht (inches) ^y	Nodes (no./plant)	Pods ^x (no./plant)	Seeds (no./pod)	Pod fresh wt (lb/acre) ^w	Estimated MG range ^v
Besweet 2020	10.1 b	9.2 b	16.9 b	2.03 a	7164 b	L-III – E-IV
Butterbean	9.1 cb	8.6 b	14.4 b	1.88 b	4046 c	L-III – E-IV
Envy	8.3 c	8.0 c	15.2 b	1.81 b	1438 c	<III
Moon Cake	28.7 a	18.9 a	57.1 a	1.87 b	19,119 a	L-V – E-VI
Mean	14.1	11.2	25.9	1.90	7942	

^zPlant height was measured from the soil level to the tip of the main stem. Fresh pods were harvested by hand.^y1 inch = 2.54 cm.^xGreen pods with seeds.^w1 lb/acre = 1.1209 kg·ha⁻¹.^vL = late, E = early.

‘Mojo Green’ and ‘Moon Cake’ were fairly similar for both planting dates, but ‘WSU-710A’ and ‘WSU-743’ reached R6 7 d earlier when planted in May than in April. Further research is required to elucidate the photoperiodic responses of these varieties.

Plant growth and development were faster in 2004 than 2005 because of the warmer temperatures at planting in June 2004 relative to that in April and early May 2005. The average maximum and minimum air temperatures for June 2004 at Stoneville, Miss., were 87 and 71 °F, respectively, compared with 75 and 55 °F for Apr. 2005 and 83 and 62 °F for May 2005 (National Weather Service, Stoneville Experiment Station). The late-maturing varieties were generally taller, had more nodes/plant, pods/plant, and total fresh pod weight than the early maturing varieties (Tables 2–5).

Fresh green bean yield in 2004 for ‘Mooncake’ was 19,119 lb/acre, whereas that for the early maturing varieties ranged from 1438 to 7164 lb/acre. In 2005, fresh bean yields ranged from 7577 lb/acre for ‘Envy’ to 39,163 lb/acre for ‘Mojo Green’ (Table 3). The yield difference between the varieties planted in both 2004 and 2005 is primarily the result of the greater number of pods per plant for the experiments. Plant height and number of nodes per plant for ‘Besweet 2020’, ‘Butterbean’, and ‘Envy’ were generally similar in 2004 and 2005, but the pods per plant were 2.3, 3.2, and 2.7 times, respectively, higher in 2005 than 2004. However, all the yield components data for ‘Moon Cake’ were higher in 2005 compared with 2004. Although we did not have June 2005 data for a direct yield comparison between

2004 and 2005, it is likely the yield differences between years were the result of differences in planting date. It is clear from the 2005 study that early planting improved yield (e.g., Tables 3 and 4). In a simulation model, Egli and Bruening (1992) demonstrated that in the absence of water stress, lower level of insolation during the reproductive growth stage was the major cause of soybean yield losses from delayed plantings. Application of supplementary water in the present study minimized any potential yield limitation by moisture deficit, but yield losses were not eliminated, indicating that other factors may be implicated. Studies in Ohio indicated that traditional soybean yield declined as planting date delayed after the first of May (Beuerlein, 1988), and similarly, Heatherly (2005) concluded that

Table 3. Plant characteristics, yield, and yield components at R6 (full seed stage) of vegetable soybean planted on clay loam soil on 18 April 2005 at Stoneville, Miss.^z

Variety	Plant ht (inches) ^y	Nodes (no./plant)	Pods ^x (no./plant)	Seeds (no./pod)	Pod fresh wt (lb/acre) ^w	Time to R6 (d)
Besweet 2020	9.5 fg	9.1 fg	37.4 fg	2.1 b	21,087 f	87
Butter Bean	7.5 gh	9.0 fg	44.3 ef	2.1 b	21,028 f	86
Envy	9.5 fg	7.7 i	27.0 h	2.0 bcd	7577 h	70
Garden Soy 01	20.9 b	14.6 b	65.5 c	2.2 a	32,298 bcd	113
Garden Soy 21	11.8 def	8.5 ghi	49.9 de	1.9 cde	34,640 ab	99
Garden Soy 24	13.4 cde	11.2 cd	54.8 d	2.0 bcd	26,770 def	87
Garden Soy 31	11.5 def	8.9 fg	54.6 d	2.0 bcd	28,010 cde	99
Garden Soy 41	10.5 ef	8.7 gh	53.7 de	1.9 cde	28,906 bcde	99
Garden Soy 42	11.7 def	9.7 ef	58.2 cd	1.9 cde	27,783 cde	87
Midori Giant	10.6 ef	10.1 e	53.3 de	2.1 bc	30,528 bcde	87
Mojo Green	14.9 c	10.5 de	82.1 b	2.2 a	39,163 a	124
Moon Cake	57.3 a	25.7 a	97.7 a	2.1 bc	33,678 abc	124
WSU-710A	12.6 cde	11.8 c	67.5 c	2.1 bc	27,768 cde	98
WSU-730A	6.7 h	7.9 hi	31.2 gh	1.9 cde	13,942 g	87
WSU-743	13.6 cd	12 c	52.6 de	2.1 bc	24,897 ef	98
Mean	14.8	11.0	55.3	2.0	26,538	96

^zPlant height was measured from the soil level to the tip of the main stem. Fresh pods were harvested by hand.^y1 inch = 2.54 cm.^xGreen pods with seeds.^w1 lb/acre = 1.1209 kg·ha⁻¹.

Table 4. Plant characteristics, yield, and yield components at R6 (full seed stage) of vegetable soybean planted on clay loam soil on 10 May 2005 at Stoneville, Miss.^z

Variety	Plant ht (inches) ^y	Nodes (no./plant)	Pods ^x (no./plant)	Seeds (no./pod)	Pod fresh wt (lb/acre) ^w	Time to R6 (d)
Besweet 2020	9.5 e	8.8 c	37.1 cde	2.0 cd	17,357 bcd	91
Garden Soy 21	10.7 cde	9.2 c	28.5 e	2.0 cd	14,919 cd	87
Garden Soy 24	8.9 ef	9.0 c	32.5 de	2.1 bc	16,512 bcd	90
Garden Soy 41	10.2 cde	9.7 c	40.7 cd	2.1 bc	18,480 bcd	ND
IA2025	13.7 b	13.4 b	47.4 bc	2.0 d	15,661 cd	90
Midori Giant	9.9 de	9.7 c	38.6 cde	2.2 a	19,545 bc	ND
Moon Cake	48 a	25.4 a	120.2 a	2.0 d	36,755 a	125
WSU-710A	11.9 bcd	13.7 b	58.0 b	2.2 a	19,119 bcd	91
WSU-730A	6.7 f	7.3 d	32.5 de	1.8 e	13,876 d	94
WSU-743	12.3 bc	12.7 b	47.3 bc	2.2 a	21,814 b	91
Mean	14.18	11.89	48.28	2.06	19,404	95

^zPlant height was measured from the soil level to the tip of the main stem. Fresh pods were harvested by hand.

^y1 inch = 2.54 cm.

^xGreen pods with seeds.

^w1 lb/acre = 1.1209 kg·ha⁻¹.

ND = not determined.

Table 5. Plant characteristics, yield, and yield components at R6 (full seed stage) of vegetable soybean planted on clay soil on 10 May 2005 at Stoneville, Miss.^z

Variety	Plant ht (inches) ^y	Nodes (no./plant)	Pods ^x (no./plant)	Seeds (no./pod)	Pod fresh wt (lb/acre) ^w	Time to R6 (d)
Besweet 2020	11.6 fg	9.9 f	41.4 gh	1.8 i	18,429 cd	92
Butter Bean	7.7 hi	8.8 g	48.3 defg	2.0 efg	16,167 de	92
Envy	14.0 def	14.1 b	55.3 cd	2.3 abc	21,101 bc	87
Garden Soy 11	14.4 cde	13.0 de	33.7 hi	2.4 a	14,449 efg	92
Garden Soy 21	12.3 efg	12.5 e	50.7 cdef	1.9 ghi	18,980 cd	ND
Garden Soy 22	13.0 defg	13.1 cde	44.9 efg	2.1 cde	16,498 de	99
IA2025	16.9 bc	14.1 bc	42.7 fg	2.0 fgh	15,242 def	ND
Midori Giant	10.5 gh	10.0 f	52.5 cde	2.1 efg	23,245 b	92
Mojo Green	17.6 b	12.5 e	76.0 a	2.0 efg	29,633 a	126
Moon Cake	56.9 a	25.8 a	64.3 b	2.0 efg	18,032 cde	126
WSU-618	10.8 g	14.1 bc	46.2 efg	2.2 bcd	16,931 de	93
WSU-706	11.4 fg	13.7 bcd	43.0 fg	1.9 hi	12,100 fg	92
WSU-710A	15.3 bcd	13.8 bcd	47.7 defg	2.1 def	15,727 def	ND
WSU-729	11.6 fg	14.5 b	58.5 bc	2.3 ab	16,468 de	94
WSU-730A	6.3 i	7.5 h	29.9 i	1.9 ghi	10,668 g	90
WSU-743	13.0 defg	12.6 e	48.7 defg	2.1 efg	18,943 cd	91
Mean	14.5	12.4	46.6	2.0	16,858	97

^zPlant height was measured from the soil level to the tip of the main stem. Fresh pods were harvested by hand.

^y1 inch = 2.54 cm.

^xGreen pods with seeds.

^w1 lb/acre = 1.1209 kg·ha⁻¹.

ND = not determined.

yields of soybean planted after May in Stoneville, Miss., were lower compared with yields for earlier planting dates. The yield data reported for some of the varieties in the present study (Tables 3–5) compare well with values ranging from 13,038 to 19,646 lb/acre for 14 vegetable soybean genotypes grown in Fort Valley, Ga. (Rao et al., 2002). In North Dakota, Duppong and Hatterman-Valenti (2005) reported a mean marketable green soybean yield of 7121 lb/acre for ‘Butterbean’ and 7644 lb/acre for ‘Envy’ grown in 2003

and 2004. The differences in yield among the three locations could be the result of differences in soil and weather conditions, planting date, and genotype.

The agronomic variables at full seed stage differed among varieties, and there was evidence that plant growth and yield for the 18 Apr. 2005 planting date were better than the 10 May 2005 planting date. For the nine varieties combined across planting dates on the clay loam soil, early planting increased plant height, number of pods/plant, and pod fresh

weight (Table 6). However, whereas the number of nodes did not differ between the planting dates, the number of seeds per pod was higher when planted on 10 May. Interaction occurred between planting date and variety indicating that the varieties did not perform similarly across planting date (Table 6). For example, unlike the other varieties, yield for ‘Moon Cake’ was higher when planted on 10 May than on 18 Apr. In addition, planting date did not affect the yield of ‘WSU-730A.’ There was also evidence of soil type by

Table 6. Analysis of variance for plant characteristics, yield, and yield components at R6 (full seed stage) of vegetable soybean cultivars planted on clay loam soil on 18 Apr. and 10 May 2005 at Stoneville, Miss.

Source	df	Plant ht	Nodes/plant	Pods/plant	Seeds/pod	Pod fresh wt/acre
<i>P > F</i>						
Planting date (P)	1	<0.0001	0.7681	0.0003	0.0047	<0.0001
Cultivar (C)	8	0.0002	0.0062	<0.0001	<0.0001	0.0002
P × C	8	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

variety interaction (Table 7). From the fresh green bean yield standpoint, 'Moon Cake', 'WSU-710A', 'WSU-730A', and 'WSU-743' performed better on clay loam soil, whereas 'Midori Giant' and 'Garden Soy 21' did better on clay soil. Yields of 'Besweet 2020' and 'IA2025' were similar on both clay loam and clay soils. In general, 'Garden Soy 01', 'Garden Soy 21', 'Midori Giant', 'Mojo Green', and 'Moon Cake' were the best-yielding varieties, whereas 'Envy' was the least-yielding variety. Thus, these five high-yielding varieties would be considered the most viable varieties for the Mississippi Delta if profitability was based on yield alone. The varieties were evaluated under irrigation conditions and yields may be lower under dry land conditions. In addition, consumer preferences for pod appearance, bean taste and texture have been documented (Johnson, 2000; Kelley and Sanchez, 2003; Lee and Hwang, 1998; Wszelaki et al., 2005) and could influence the price and the willingness to purchase a particular vegetable soybean variety. Thus, additional studies would be necessary to evaluate irrigation requirements, and also pod appearance and sensory quality attributes in relation to desirability, to make a valid conclusion about the most profitable varieties for the Mississippi Delta.

The pods on plants allowed to reach full maturity exhibited high degree of shattering, thus uniform emergence and timely harvest of the dry beans may be essential for edamame seed producers. No disease symptoms were visually observed suggesting that yields in both years were not limited by disease pressure. The short growing periods of some of the vegetable soybean varieties, in particular 'Envy', make them suitable for use in a double-crop system or for growers who want to capitalize on the early market.

One of the many challenges producers face when considering new

crops is the lack of reliable profitability estimates. Differences in production practices and harvest cost greatly influence returns, and in particular, the actual market prices for new crops are often difficult to estimate (Ernst and Woods, 2001). Using the Mississippi State Budget Generator (Laughlin and Spurlock, 2005) as a guide, economic analyses were conducted to evaluate returns over variable and fixed production costs for vegetable soybean. We estimated total production cost (cost of seeds, fuel, irrigation, hired labor for harvesting, and so on, cooling, repair and maintenance of equipment etc) as \$3472/acre (Table 8). This did not include costs for land, management, and overhead. Harvesting was done manually by hand because of lack of harvesting machinery; hence, most of the labor cost was associated with harvesting. Farm gate price for fresh beans was estimated as one-third of the prices on the local retail market (average

\$1.50/lb). Conservative estimation, therefore, indicated that for an average yield of 7942 lb/acre in 2004, net returns of \$499/acre above the specified costs could be obtained from vegetable soybean production. Conservative budget estimates for vegetable soybean production in Kentucky indicated potential net returns of \$400 to \$2500/acre for wholesale fresh market beans (Ernst, 2001). The estimated net returns for the present study indicated about twice the returns (average \$150–250/acre) from regular soybean production in the Mississippi Delta.

Conclusion

Soybean as a green vegetable has a great potential in the U.S. The results from this study indicated that vegetable soybean could be successfully grown in the Mississippi Delta. Growth and yield for the mid-April and early May planting dates were better than the early June planting. Considering the growth duration, groups III and IV may fit well to the growing season in the midsouthern U.S. and will also take advantage of the early market demand. Yields and estimated net returns from vegetable soybeans are promising in Mississippi, but the major problems are the labor-intensive nature of production, limited consumer base or well-established

Table 7. Analysis of variance for plant characteristics, yield, and yield components at R6 (full seed stage) of vegetable soybean cultivars planted on clay loam and clay soils on 10 May 2005 at Stoneville, Miss.

Source	df	Plant ht	Nodes/plant	Pods/plant	Seeds/pod	Pod fresh wt/acre
<i>P > F</i>						
Soil type (S)	1	<0.0001	0.0021	0.0217	0.0031	0.0059
Cultivar (C)	8	0.0067	0.0132	<0.0001	<0.0101	<0.0001
S × C	8	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 8. Estimated budget for 1 acre (0.4 ha) of vegetable soybean grown in Stoneville, Miss., in 2004.

Item	Estimated amount ^a
Average yield	7942 lb
Farm gate price	\$0.50/lb
Gross returns	\$3971
Preharvest costs (seeds, cultivation, weed control, irrigation, and repair and maintenance of equipment)	\$1972
Harvesting, handling and storage including cooling	\$1500
Total specific cost	\$3472
Net returns above specified cost	\$499

^a1 lb/acre = 1.1209 kg·ha⁻¹, \$1.00/lb = \$2.2046/kg, \$1.00/acre = \$2.4711/ha.

marketing channels, and lack of processing facilities. However, as awareness of the nutritional and health benefits of vegetable soybean increases, these problems may be solved to help increase production. Research aimed at variety selection based on flavor, texture, and other characteristics could help increase consumer preference and consumption.

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