Washington State University Edamame Trials 2000

Carol A. Miles and Chuhe Chen
WSU Vancouver Research and Extension Unit, 1919 NE 78th Street, Vancouver WA 98665
Phone: 360-576-6030 Fax: 360-576-6032 Email: milesc@wsu.edu

In 2000, we continued our research studies of edamame with four separate trials at three different locations, WSU Vancouver Research Extension Unit (VREU), OSU North Willamette Research and Extension Center (NWREC), and a commercial farm in the Willamette Valley. Additionally, we sampled edamame at all trial locations as well as in commercial fields in eastern Washington for pest problems.

1) variety trial – WSU VREU
2) nutrient composition trial – WSU VREU and OSU NWREC
3) Nitrogen (N) trial – OSU NWREC
4) On-farm mechanical harvesting trial – commercial farm, Willamette Valley
5) Pest survey – all trial locations and commercial fields in eastern Washington

At OSU NWREC, our collaborator is Dr. Del Hemphill, Vegetable Research Specialist.

VARIETY TRIAL

The variety trial was planted at WSU VREU and included 15 commercial varieties from six seed companies, plus 4 breeding lines from the Asian Vegetable Research and Development Center (AVRDC), for a total of 19 entries. The experiment had a randomized complete block design with four replications. Plots were double-row beds, 20 feet in length (6 m), on 5-foot (1.5 m) centers. Seeds were spaced 3 inches (7.5 cm) apart in the row.

Planting and Maintenance The field was tilled in mid-May 2000 in preparation for planting. A 35-10-10 fertilizer was applied and incorporated at a rate of 50 lb N/A. The trial was planted on May 24, 2000. Prior to planting, seed was inoculated with *Bradyrhizobium japonicum*. The rhizobium powder was wetted to better coat the seeds. Plots were mechanically cultivated for weed control between rows and hand weeded to control in-row weeds once a month from June to August. Overhead irrigation was applied weekly (as needed) throughout the growing season. Plant stand was counted in early July. In July and August, flowering dates were observed.

Harvest Harvest began on August 31, 2000, and continued through September 28. Plants were harvested from 10 feet (3 m) of row in the center of each plot to estimate yield. Pods were hand picked from the harvested plants and sorted into three quality categories: 1) marketable pods with two or more beans per pod; 2) pods with only one bean; and 3) unmarketable pods. Each category of pods was weighed. 100 pods were taken from the category with 2 or more beans per pod, and weighed. From those 100 pods, the beans were removed from 25 of the pods. These individual beans were then weighed and counted. 100g of fresh beans were collected from this same category and sent to Marie Bumback at WSU Department of Crops and Soils, Pullman for nutrient analyses.

Taste Test A blind taste test was conducted of all harvested varieties at WSU VREU. We boiled unshelled edamame pods for 3 to 5 minutes. Cooked, unshelled edamame pods of each variety were randomly arranged for taste sampling. Thirteen participants were each given a survey sheet on which to write their opinions of each variety, and were asked to identify their favorite variety, and why they chose that particular variety.

Results

Plant Stands Plant stands continue to be below expected values of 120 plants per 10 feet of row (Table 1). In laboratory assays, seed germination is high, therefore we suspect a soil environment interaction that inhibits seedling emergence. The varieties Kitanosuzu, Gion and Sayamusume had the best establishment this year, and this contributed to the high pod yield of Kitanosuzu and Sayamusume. The variety White Lion and all 4 breeding lines had very poor establishment, and only one breeding line, AGS 91027-6-2-3, had enough plants for yield evaluation. The variety Shironomai had average plant establishment yet achieved a very high pod yield, indicating its compensation ability and yield potential.

Flowering The variety Envy flowered first, and attained 50% flowering on August 1 (Table 1). Most other varieties flowered within the following week, and 50% flowering was accomplished by August 7. The variety Kegon flowered on August 7 and pods did not mature for harvest before a killing frost at the end of September. The other late flowering variety, Lucky Lion, produced a moderate yield, indicating it has a quicker seed ripening period. The variety Sayanishiki was flowering when other varieties were being harvested (data not shown).

Plant and Pod Heights The overall average plant height for all commercial varieties was 36.6 cm. The variety Shironomai had the highest plant height, and one AVRDC breeding line, 91027-6-2-3, was significantly taller (2 times taller) than all varieties (Table 1).

The overall average height from the ground to the lowest pods for all varieties was 10.6 cm. The variety Shironomai had the greatest height from the ground to the lowest pod compared to other varieties. The distance from the ground to the lowest pod is significant when considering variety suitability for mechanical harvesting. Pods that are too low to the ground will not be harvested and thus will not contribute to yield. Based on these measurements, Shironomai may be a good candidate for machine harvesting and large-scale production. The varieties Kitanosuzu and Sayamusume had medium plant height and pod position, and thus may not be suitable for machine harvesting. The varieties Envy, White Lion, and SB 1200 may not be suited to machine harvesting due to their low plant height and pod position.

Yield In 2000 the variety trial at WSU VREU achieved the highest marketable yields as compared to our edamame trials of preceding years (Table 2). The improved inoculation procedure used in combination with weekly irrigations may have contributed to these results. The variety Shironomai was consistently high yielding over the four years it was included in our trials. The varieties Sayamusume, Butterbeans, Kitanosuzu, Lucky Lion, Gion, and White Lion were also high yielding (greater than 500g) over the 5-year period. The varieties Sayanishiki and Kegon did not mature and were eliminated from the comparison because they lacked yield data.

The varieties Kitanosuzu, Sayamusume and Shironomai produced high marketable yields (pods with 2 or more beans) (greater than 800g per 10 feet of row), and the yields of Kenko and Gion were also good (greater than 700g) (Table 3). The varieties Kitanosuzu and Sayamusume produced high marketable pod yields in both 1999 and 2000.

The varieties Sayamusume, Shironomai, and Kenko produced large pods where 100 pods weighed close to 300 grams. Sayamusume and Kenko also produced the largest pods in 1999 (data not shown). The weight of 25 beans should be equal to or greater than 20 grams for the fresh vegetable market. In 2000, all varieties were below this criterion, perhaps due to our irrigation practices. Bean weights of different varieties were not statistically different, perhaps due to small sample size. Next year we will measure bean weights from 50 pods.

Taste Evaluations Our taste evaluations were conducted by our research station colleagues who have no experience with edamame flavor or texture. In these evaluations, the variety Kenko received the most votes (5) for its sweet and buttery smooth flavor, and meaty texture (data not shown). The variety Shironomai received two votes for sweet and rich flavor. None of the varieties were found to be distasteful or unappealing. Our results indicate that a consumer audience that is unfamiliar with edamame found all the varieties to be similar in flavor and texture, and acceptable.

Discussion The varieties Shironomai, Kitanosuzu, Sayamusume and Kenko performed best in our trials in 2000. They were the highest yielding with the largest pod weights. Shironomai also appeared to be most suitable for mechanical harvest based on the distance from the ground to the lowest pods.

Nutrient Trial

This study was planted on behalf of Marie Bumback, a graduate student working with Tom Lumpkin, WSU Department of Crops and Soils, Pullman. The objectives of the study were to analyze varieties for isoflavone and nutrient contents. The trial was planted at WSU VREU and OSU NWREC. This trial included 6 varieties and was planted in a randomized complete block design with 4 replications at both locations. Plots were 4 rows wide and 20 feet in length (6 m). Seeds were spaced 3 inches (7.5 cm) apart in the row.

Planting and Maintenance At WSU VREU, a 35-10-10 fertilizer was applied and incorporated at a rate of 50 lb N/A and the trial was planted on May 24, 2000. At OSU NWREC, the field was fertilized with triple super phosphate and sulfate of potassium at the rates of 200 lb/A each, nitrogen was applied at the rate of 50 lbs N/A, and the trial was planted on May 25. Prior to planting at both locations, seed was inoculated with *Bradyrhizobium japonicum*. At OSU NWREC, herbicides were applied for weed control, while at WSU VREC plots were mechanically cultivated for weed control between rows and hand weeded to control in-row weeds once a month from June to August. At both locations, overhead irrigation was applied weekly (as needed) throughout the growing season.

Harvest Harvest began on August 31 and continued through September 28 at WSU VREU. At OSU NWREC the trial was harvested on September 12. At both locations, plants were harvested from 10 feet of row in the center of each plot. Pods were hand picked from the harvested plants and weighed. 100g of shelled beans were collected from both locations and sent to Marie Bumback for analyses.

NITROGEN TRIAL

At OSU NWREC, we planted one variety, Butterbeans, and tested the efficacies of rhizobium inoculum and nitrogen (N) fertilizer levels. The trial included two rhizobium treatments (with and without) and 4 N treatments (0, 36, 72 and 108 lb N/acre). The trial was planted on May 26, 2000 in a randomized split plot design with 4 replications. The inoculum treatments were the main plots and N treatments were the subplots. The subplot was 15 X 20 feet in size, and was 7 rows wide with an in-row spacing of 3 inches. Triple super phosphate and sulfate of potassium fertilizers were applied at the rates of 200 lb/A each.

Harvest Plants were harvested on September 12. Plants from a total of 10 feet of row in the center of each plot were harvested by hand. Plants were counted and pods were hand picked from the harvested plants and sorted into three quality categories: 1) marketable pods with two or more beans per pod; 2) pods with only one bean; and 3) unmarketable pods. Each category of pods was weighed. 150 pods were taken from the category with 2 or more beans per pod, and weighed. From those 150 pods, the beans were removed from 25 of the pods. These individual beans were then weighed and counted. 150g of fresh beans from each plot were sent to Marie Bumback, WSU Department of Crops and Soils, Pullman, for nutrient analyses.

Results

Rhizobium inoculation There were no significant differences between the rhizobium inoculated and non-inoculated treatments (Table 4).

Yield The 40 and 0 kg/ha N treatments produced the highest marketable yields (Table 4). The 120 kg/ha N treatment produced the fewest number of beans. There were no statistical differences in any of the other yield components in response to N level.

Discussion The lack of response to rhizobium inoculation combined with the high yield of the 0 N treatment suggest that the field may have high rhizobium populations in the soil.

ON-FARM MECHANICAL HARVESTING TRIAL

The variety Shironomai was planted by a commercial vegetable farmer in the Willamette Valley. Edamame was mechanically harvested September 29, and harvesting efficacy was low (50%). In order for edamame to become a large-scale commercial crop in the US, mechanical harvesting is essential. In our studies at WSU VREU, Shironomai had the highest distance from the ground to the lowest pod, indicating it should be most suitable for mechanical harvest. Emphasis should be placed on adjusting the harvester to improve efficiency or testing another harvester.

PEST SURVEY

Edamame plant samples were collected at all sites where apparent pest damage symptoms were observed. Samples were analyzed at Oregon State University and at Agdia Incorporated in Indiana, a laboratory specializing in soybean disease analysis.

1. At OSU NWREC, *Diabrotica* (cucumber beetle) leaf feeding damage was observed in late June. Plants did not exhibit disease or other insect feeding symptoms in 2000.

2. Edamame plant samples were collected by Cascadian Farms in early July from a commercial field in eastern Washington. Samples were sent to Melodie Putnam, Diagnostic Plant Pathologist, and Kathy Merrifield, Extension Nematologist, at Oregon State University for analysis. Plant symptoms included severe leaf cupping and interveinal puckering similar to what is produced by pesticide injury. However, presumably no pesticides were used on this site for several years as it is certified organic. Leaves exhibited leaf crinkling but no evidence of disease was isolated. No plant-parasitic nematodes were found in any of the samples. Plants exhibited scarring from thrips injury, but only one thrips was isolated. No mites were found on any of the samples. There are apparently reports from the mid-west of soybean leaf cupping in the absence of herbicide use. It was suggested that this occurs when there is an imbalance of a plant hormone response normally regulated in the apical meristem. This phenomenon is not understood.

3. We collected samples of plants that appeared to be suffering from pest damage on August 9 at WSU VREU. Samples were sent to Melodie Putnam at Oregon State University. All plants had leaf puckering along the veins. Four of the plants looked as if they may be suffering from nutrient deficiency. Symptoms included overall chlorosis, interveinal yellowing and bronzing, chlorotic mottling of the leaves, small root systems, and although nodules were large, they were few in number. There was also some decay of the secondary roots caused by *Rhizoctonia*. One plant also showed insect feeding injury to the taproot, which was then colonized by *Rhizoctonia* and other fungi.

Some plants had a strong yellow mottle in leaves of intermediate age. Some leaves were distorted from uneven growth on either side of the mid-rib, and roots though not abundant showed no sign of disease. Chlorotic mottling of the younger leaves on one plant suggested virus infection. One plant had a small necrotic leaf lesion surrounded by a narrow yellow halo. There was also a brown, sunken stem lesion present. A bacterium was isolated that may have caused the lesions, but ss yet, this bacterium has not been identified. Plants were tested serologically for the presence of any potyviruses, the group to which bean yellow mosaic virus and soybean mosaic belong. No viruses were detected in any of the samples.

4. On September 8, plant samples were collected from WSU VREU and sent to Agdia Incorporated for analysis for 15 viruses known to infect soybeans. All tests were negative.

Table 1. Plant establishment and some morphological characteristics of the varieties and breeding lines tested at WSU Vancouver in 2000.

Genotype	Plant height (cm)	Distance from ground to the first marketable pod (cm)	No. Plants per plot	Date of 50% flowering
Yukimusume	31.9 bc†	8.6 bc	99 abc	8/5
White Lion	25.9 c	8.8 bc	51 fg	8/4
Shironomai	45.3 a	14.0 a	88 cde	8/4
SB 1002	25.7 c	7.7 c	64 def	8/7
Sayamusume	31.9 ab	11.5 abc	109 abc	8/4
Sapporo Midori	31.6 bc	10.0 abc	90 bcde	8/4
Misono-Green	37.9 bc	9.4 bc	90 bcde	8/5
Lucky Lion	36.9 ab	9.3 bc	90 cde	8/6
Kitanosuzu	33.2 bc	11.2 abc	125 a	8/4
Kenko (SE-4)	38.7 ab	11.7 abc	83 cdef	8/4
Kegon	38.2 ab	12.3 ab	80 cdef	8/7
Gion	37.8 ab	10.6 abc	124 ab	8/3
Envy	37.9 ab	8.7 bc	93 abcd	8/1
Butterbeans	36.9 ab	10.1 abc	55 ef	8/4
AGS 93037-15-1	34.1 bc	10.9 abc	16 g	8/4
AGS 91027-6-2-3	30.2 bc	9.2 bc	52 f	8/3

†, Means with different characters are significant at P=0.05 level by Tukey's HSD test.

Table 2. Marketable yields (g) in 10 feet row of edamame varieties grown at Chehalis, 1995-99, and WSU Vancouver REU, 2000; and average yields over 2-5 years.

Genotype	1995	1996	1997	1999	2000	Mean
Yukimusume				154	529	342
White Lion	810	731	585	212	324	532
Shironomai	743	728	931		835	809
Shirofumi	220		586			403
SB 1002				90	341	216
Sayamusume	699			202	852	584
Sapporo Midori		408	397	138	431	344
Mikawahima 202			321			321
Lucky Lion	614	736	593	183	625	550
Kitanosuzu				226	923	575
Kenko (SE-4)				95	778	437
Gion	687	321	735	198	753	539
Fiskeby V	631	61				346
Envy	332		379		478	396
Early Hakucho	495	120	468			361
Butterbeans	663	770	617	327	501	576
AGS 91027-6-2-3				263	210	237

Table 3. Edamame marketable (pods with 2-3 beans) and unmarketable yields (g) and yield components in 10-feet row of varieties grown at WSU Vancouver REU in 2000.

Genotype	Wt. of pods with 2-3 beans	Wt. of pods with 1 bean	Wt. Of un-marketable pods	Wt of 100 pods	Wt of beans from 25 pods	# of beans from 25 pods	Wt. Of 25 beans
Yukimusume	529.4 ab†	230.3 abc	77.6 a	278.5 ab	40.1 a	62.5 ab	15.9 a
White Lion	323.6 ab	57.4 c	25.0 a	249.0 ab	34.5 a	59.5 ab	14.5 a
Shironomai	835.3 ab	336.3 a	110.0 a	315.0 a	39.3 a	58.3 b	16.7 a
SB 1002	340.9 ab	69.0 bc	42.8 a	222.8 ab	32.6 a	58.0 b	13.9 a
Sayamusume	852.4 ab	139.2 bc	58.0 a	314.5 a	42.5 a	61.5 ab	17.2 a
Sapporo Midori	430.8 ab	97.2 bc	61.5 a	268.0 ab	38.8 a	62.8 ab	15.5 a
Misono-Green	484.3 ab	191.5 abc	80.0 a	268.8 ab	38.0 a	61.3 ab	15.9 a
Lucky Lion	624.6 ab	191.5 abc	96.3 a	262.3 ab	36.3 a	57.5 b	15.9 a
Kitanosuzu	923.3 a	187.0 abc	104.8 a	271.8 ab	40.0 a	71.0 a	14.1 a
Kenko (SE-4)	778.3 ab	320.0 a	102.0 a	299.3 a	37.5 a	55.3 b	16.9 a
Gion	753.1 ab	247.0 ab	92.5 a	274.0 ab	39.3 a	59.8 ab	16.7 a
Envy	478.2 ab	209.5 abc	90.3 a	200.5 b	25.6 a	54.0 b	11.9 a
Butterbeans	501.1 ab	161.7 abc	68.7 a	256.8 ab	30.9 a	58.8 b	13.1 a
AGS 91027-6-2-3	209.5 b	93.3 bc	102.8 a	249.0 ab	36.5 a	56.0 b	16.0 a

†, Means with different characters are significant at P=0.05 level by Tukey's HSD test.

Table 4. Edamame marketable (pods with 2-3 beans) and unmarketable yields (g), and yield components in 10-feet row in response to nitrogen levels and rhizobium inoculation at OSU NWREC in 2000.

Treatmnet	Plant # /row	Wt. of pods with 2-3 beans	Wt. of pods with 1 bean	Wt. Of un-marketable pods	Wt of 100 pods	Wt of beans from 25 pods	# of beans from 25 pods
N kg/ha:							
0	21.0 a†	572.6 a	267.6 a	88.3 a	337.5 a	29.5 a	59.6 a
40	21.6 a	606.6 a	314.0 a	120.8 a	359.0 a	29.2 a	55.9 ab
80	22.8 a	425.5 b	253.0 a	150.8 a	365.4 a	26.2 a	55.9 ab
120	22.3 a	392.0 b	262.1 a	136.0 a	335.5 a	25.1 a	50.1 b
Inoculum:							
Without	23.3 a	516.5 a	275.0 a	103.2 a	339.3 a	27.3 a	55.4 a
With	20.6 a	483.9 a	273.5 a	142.2 a	357.7 a	27.7 a	55.7 a

†, Means with different characters are significant at P=0.05 level by Tukey's HSD test.