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ORGANIC SOYBEAN PRODUCTION IN ATLANTIC CANADA

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INTRODUCTION

Organic soybean production has not been widely adopted in the Maritimes despite growing demand in the food and feed markets. Challenges in organic soybean production include sourcing organic seed, finding varieties with appropriate heat unit requirements, weed control, and marketing. In this bulletin we provide a brief review of considerations for organic soybean production, and summarize the results of organic varietal trials conducted in the Maritimes in 2006 and 2007.

Soybean is an ancient Japanese crop that has been adapted to grow in many different regions around the world. Its high protein content (40-45%) has made it desirable for both animal feed and human food. It also has a high oil content making it useful for food, industrial applications and fuel. The type of soybean grown can have a large impact on its qualities for different uses. These qualities, and hence the marketability of the soybean, are also affected by management.

SOYBEAN VARIETIES

Your selection of soybean varieties should be based on both your market and local growing conditions. Important characteristics to consider include: heat requirement (days to maturity), protein and oil content, hilum colour, bean size and shape, yield, branching, resistance to diseases and lodging, and height to the lowest pod.

Protein and oil content influence the suitability of the soybean for different uses, and the characteristics of the final product. For example, a high protein-to-oil ratio will result in a firm tofu and a low protein-to-oil ratio will produce a silken tofu. The L2 and L3 lipoxygenase enzymes are also important to tofu producers. These compounds are responsible for the beany aroma and flavour in soymilk and tofu.

Height to the lowest pod will influence soybean yield (A. Hammermeister)

Crop breeders are now working on ways to reduce the amount of these compounds in certain varieties.

Soybeans vary widely in their **heat unit requirements**; select a suitable variety for your location and management practices (e.g. if you seed late to allow weed control). Growing a long season bean in a short season climate could result in a crop that will not mature. Soybeans are considered to be a **heat-loving** plant, typically planted after the first frost-free day in the spring around the first of June. This later planting makes it very important for the soybean plants to emerge and grow quickly. When seedlings establish and emerge quickly, they are expected to be more competitive with weeds.

The **hilum** is the point on the seed where it connects to the pod. The color at this point is important for food grade uses because the hilum color can stain the seed. Hilum colors may be clear, imperfect yellow, yellow, brown or black. The hilum colour may cause the milk and meal of the soybean to have gray shades. Most consumers find a gray colour in their products

less appealing. Processors prefer different sizes and shapes of soybean for different uses. Round beans are preferred over kidney shaped and larger beans are better for tofu. Be sure to ask your buyer if they have a preference.

Soybean varieties can vary in how quickly they emerge; however, seedbed preparation, seeding depth and soil conditions are important for good crop establishment. Soybean branching is partially a varietal trait, but is also influenced by seeding rate and row spacing. Branching varieties will have faster canopy closure, making them more competitive with weeds. However, branching varieties may have lower pods and less even maturity. Pod height is an important consideration for harvestability. Pods higher off the ground are more likely to be harvested and less likely to be stained.

Mudtagging is a term used to describe the condition of the beans after a moist, dirty harvest. Juices from lush weeds or damp conditions at harvest can make the beans sticky, causing them to collect dust. Staining and mud tagging caused by weeds during harvest can significantly reduce marketability and price. Harvesting beans under dry conditions after the plants and weeds have died will minimize mudtagging and staining. Some row-cropping farmers trim the tops off of weeds just before the crop canopy closes. Recent research conducted by AAFC in Ottawa has shown that moisture availability during the early pod development stages (stages R4-R5) is the most important factor affecting yield. Weed competition for moisture at this stage could have a large yield impact.

SOYBEANS AS FEED

For feed purposes, protein and oil affect nutritional and energy values. Soybeans are the number one source of protein used in animal feeds. Higher oil levels will reduce the amount of dust in the feed. Compounds in the soybean called trypsin inhibitors and urease make the beans indigestible for monogastric animals and ruminants. Heat processing of the beans will break down these compounds and increase digestibility without damaging the feed quality: roasting and extruding are two common methods. Roasting requires the beans to pass through hot air to raise the temperature to 160^{o}C. It is also very important that the beans are steeped; a process where the beans are held at or close to the roasted temperature for a period of time. Extruded beans are heated by the friction of pushing the beans through a very small hole. This produces two products: soybean meal and soybean oil.

SOYBEAN TRIALS

A two year trial was conducted by the Organic Agriculture Centre of Canada to assess the production of different soybean varieties under organic management in the Maritimes. The research goal was to determine the suitability of varieties for organic production and assess the importance of row spacing.

Twelve varieties (Table 1) were grown over 2 years in replicated small plots in PEI and NS. The varieties AC Glengarry and Windfall were only grown in 2006; Bicentennial, Toki and NK S03W4 were only grown in 2007. We used certified seed in all trials, and the varieties Prudence, NKS-080, OAC Champion and NK S03W4 were also certified organic. Typical weed control in organic soybeans has relied on the use of a good crop rotation and planting in a weed-free field. In addition to these practices, we tested the use of wider row spacing to allow inter-row cultivation.

Table 1. 2006 & 2007 variety characteristics and seeding rates for organic soybean trials

Variety	Heat Unit Rating	Hilum Colour	TKW (g)		Seed Rate[Z] (kg ha^{-1})		
	(CHU)		2006	2007	15 cm	30 cm	45 cm
OAC Prudence[1]	2450	Y	200	198	103	108	83
Bicentennial[2]	2600		n.t	204	104	n.t	83
Ugo[2]		Y	193	157	79	104	63
Atwood[2]	2600	Y	183	190	183	98	146
Baron[2]	2600	B	161	169	87	87	69
AC Glengarry[1]	2600	IY	165	n.t	103	89	n.t
OAC Champion[1]	2700	IY	192	202	105	103	84
Windfall[2]	2750	IY	251	n.t	157	135	n.t
NK S08-80[1]	2750	Y	213	206	107	114	86
Toki[3]	2700	Y	n.t	203	102	n.t	82
OAC Vision[4]	2250	B	151	n.t	94	81	n.t
NK S03W4[1]	2650	Y	n.t	174	89	n.t	71

[Z]At 80% establishment rate, 40 seeds m^{-2} in 45-cm rows, 43 seeds m^{-2} in 30-cm rows, 50 seeds m^{-2} in 15-cm rows
[1]Homestead Organics (ON), [2]MeadowBrook Farms (PE), [3]Seed from Agriculture and Agrifood Canada, not yet released
[4]Eliminated from trial due to poor seed germination
Y- yellow IY - imperfect yellow, B – brown, n.t – not in trial

The row width used will depend largely on the variety grown, as some varieties will establish and branch more quickly than others. The choice of appropriate row spacing will influence weed competition. Small plots were established with two treatments: narrow 15-cm rows and wide 45-cm rows (30 cm in 2006). The 30-cm row width was replaced with 45-cm rows to better suit the equipment available for interrow cultivation. 2007 plots for both narrow and wide row spacing were located at the Brookside research field in Truro, NS and Barnyard Organics in Freetown PEI.

In 2007, the soybeans were seeded at 54 seeds m^{-2} at 45-cm row spacing and 63 seeds m^{-2} at 15-cm row spacing. Assuming an 80% germination and emergence rate, this would correspond to approximately 40 seeds m^{-2} in 45-cm rows and 50 seeds m^{-2} in 15-cm rows. Both treatments were fingerweeded before emergence, at the first trifoliate and the second trifoliate (trifoliate - a stage of growth of soybean plants where three leaves branch off the main stem). The 45-cm spacing was then cultivated twice more to further disturb the weeds.

VARIETY AND ROW SPACING TRIAL RESULTS

Time to maturity is critical in selecting soybean varieties. The short growing season of the Maritime region limits the grower to shorter season crops. Soybeans planted with narrow row spacing will mature earlier than wider rows because the plant will produce fewer branches. Days to maturity is calculated from the date of planting until 95% of the pods are brown. Suggested harvest time is usually about a week after maturity. The varieties tested ranged from 120 to 130 days to maturity at the 30 or 45-cm row spacing. Once the beans mature, the beans dry down and can go into storage. Soybeans should be stored at 13-14% moisture. Harvesting as close to that moisture content as possible will minimize drying costs. However, care must be taken to avoid damaging the seed during harvest and handling if it is below 15% moisture.

If the first pod is higher off the ground, yield will be higher and there could be a reduction of mud tagging. Four out of the nine varieties tested showed higher pods at 15-cm spacing compared to 45-cm spacing. At the PEI site, height to the first pod was lowest for OAC Prudence and Ugo in the 15-cm rows. The new variety Toki showed the highest pods with approximately 2 cm over the other varieties tested in the 15-cm spacing but not in the 45-cm rows. At closer row spacing, the plants stretch upwards and compete for light. Plants will tend to be bushier in wide rows. The varieties also differed in height to the lowest pod. Atwood and Barren were especially low to the ground in 45-cm rows; NK S08-80, Toki and NK S-03W4 were notably higher off of the ground at 15-cm spacing. OAC Champion and NK S08-80 were higher off the ground in the 45-cm rows.

Table 2. Soybean variety trial yield results (kg ha^{-1}) for different sites and row spacing in 2006 & 2007

Variety	2006				2007							
	Site A&B		Site B&C		Site PEI				Site NS			
	15-cm		30-cm		15-cm		45-cm		15-cm		45-cm	
OAC Prudence[1]	2097	bc	2370	bc	2412	c	2936	a	476	cd	868	d
Bicentennial[3]	n/a		n/a		2802	bc	2813	ab	1347	ab	1897	ab
Ugo[1]	1583	cd	1442	e	2483	c	2772	ab	1014	bc	1347	c
OAC Atwood[1]	1199	d	1249	e	1507	d	1283	d	160	d	344	e
Baron[1]	1827	cd	1399	e	1787	d	2292	bc	431	cd	725	de
AC Glengarry[2]	2379	ab	2829	ab	n/a		n/a		n/a		n/a	
OAC Champion[1]	2685	a	2975	a	2526	c	2711	abc	1476	ab	1863	b
Windfall[2]	1718	cd	1720	de	n/a		n/a		n/a		n/a	
NK S08-80[1]	2057	bc	2184	cd	1386	d	2156	c	1518	ab	1334	c
Toki[3]	n/a		n/a		3357	a	2884	ab	1935	a	2008	ab
NK S03W4[3]	n/a		n/a		2037	ab	2940	a	1963	a	2298	a

[1]Variety in 2006 & 2007 trial. [2] Variety only in 2006 trial. [3]Variety only in 2007 trial
a-e Yield values within the same column and followed by the same letter are not statistically different (P<0.05)
Note: Yields for the two row spacings in 2006 should not be compared because they were measured at different sites
NB Results for OAC Vision are not reported here, as the seed used for the trial was poor

Organic soybean fields in Prince Edward Island (A. Hammermeister)

In 2006, there was no clear difference in yield between row spacing (measured at one site); however, there were differences in varieties. In 2007, when compared at the same site (NS or PEI), row spacing and soybean variety each had a significant effect on yield (but the interaction was not significant). The 45-cm rows had significantly higher yield than the 15-cm rows, although yield varied considerably among varieties and sites (Table 2). In Truro, yield for OAC Atwood and Baron was significantly lower than all varieties but OAC Prudence, regardless of spacing. OAC Prudence performed better in 2007 at the PEI site and at both sites in 2006, while OAC Atwood and Baron performed poorly across the board. Generally, OAC Champion produced high yield regardless of site or row spacing. Bicentennial, Toki, and NK S03W4 were also promising introductions in 2007. Cultivar selection for yield is strongly influenced by row spacing and weed management.

Research has consistently shown that narrower row spacing produces higher yields, but these trials are typically conducted under weed-free conditions. The results from this trial would suggest the opposite may be true in organic systems. Planting in narrow rows does not permit mid-season weed control between rows; a clean field, good seed bed conditions, and timely weeding with tine harrows or rotary hoes are critical when planting at narrow spacing.

THE BOTTOM LINE...

Soybean varieties should be carefully selected based on local environmental conditions, row spacing, end use and other characteristics required by the buyer. Planting in 30-45 cm rows (6-18 in) can provide a yield advantage and more effective weed control. Planting in narrow rows can be attempted with a good seedbed, clean field and early mechanical weeding.

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