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BRASSICA TRIALS

2004-2012

ABIGAIL A. MAYNARD, PH.D.

and JEFFREY S. WARD, PH.D.

Department of Forestry and Horticulture

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ABSTRACT

Cultivar trials were conducted on 19 cultivars of cauliflower in 2004-2006 (spring and fall), 14 cultivars of Chinese cabbage (spring and fall) in 2007-2008, 13 cultivars of pak choi (spring and fall) in 2009-2011, and 12 cultivars of broccoli (spring only) in 2012-2014. Trials were carried out on a sandy terrace soil (Windsor, CT) and a loamy upland soil (Hamden, CT). Average yields reported are those combining both sites. Cauliflower yields were greater in the spring than in the fall: 7.2 T/ and 6.1 T/A, respectively. Freedom, Attribute, and Minuteman produced both high quality heads and high yields in both seasons. Cultivars with poor quality heads included Phoenix, Snow Grace, First White, Early White, and Baldo. Chinese cabbage yields were greater in the fall than spring: 14.3 T/A and 11.6 T/A, respectively. Lower yields in the spring were due to many of the cultivars bolting. Bilko, Blues, and Nikko produced both high quality heads and high yields in both seasons. Rubicon also produced consistently high quality heads with slightly smaller yields. Pak choi yields were 10.2 T/A in the spring and 9.0 T/A in the fall. Seven of the thirteen cultivars bolted in the spring. Joi choi, Win Win choi, and Fuyu Shomi produced consistently high yields and good quality heads. Spring broccoli yields ranged from 6.3 T/A in 2012 to 5.3 T/A and 2.4 T/A in 2014 and 2013, respectively. Imperial, Avenger, Diplomat, Bay Meadows, and Blue Wind produced high yielding excellent quality heads. Cultivars producing poor quality heads included Maximo, Concord, Coronado, and Emerald Jewel.

The economic potential of these crops can be very high for growers who sell directly to the consumer. Based on the production in our trials, spring planting the highest yielding varieties can provide the grower a gross income for cauliflower of \$28,943/A (at \$2.99/head), Chinese cabbage of \$76,416/A (at \$1.99/lb), pak choi of \$92,734/A (at \$1.99/lb), and broccoli of \$33,864/A (at \$2.49/lb). Fall planting the highest yielding varieties can provide a gross income for cauliflower of \$28,943/A (at \$2.99/head), Chinese cabbage of \$87,162/A (at \$1.99/lb), and pak choi of \$50,546/A (at \$1.99/lb).

INTRODUCTION

Brassica is a genus of plants consisting of 37 species that are in the Brassicaceae or mustard family. Members of this genus are also called cruciferous vegetables, cabbages, or cole crops. The genus is known for its important agricultural and horticultural crops that also include a number of weeds. *Brassica* species commonly used for food include broccoli, cauliflower, cabbage, rutabaga, turnip, Brussel's sprouts, kale, as well as Chinese vegetables such as Chinese cabbage and Pak choi. Additionally, Brassica seeds are used in the production of canola oil and mustard.

Although Brassicas can be grown throughout the growing season, they do best in the cooler weather of the spring and fall. Spring production can be especially problematic when the warmer temperatures of early summer could lead to the crop bolting. Bolting occurs in susceptible plants when the ground temperature rises above a critical temperature. This can cause the plant to almost completely abandon leaf growth and rapidly switch to producing flowers and seeds. Once a plant has fully bolted, the plant is usually inedible. As the plant's entire energy reserve is focused on producing the seeds, the rest of the plant tends to become tough, woody, and often tasteless or even bitter. Bolting is a survival mechanism in a plant. When the weather gets to be above where the plant will survive, it will try to produce the next generation (seeds) as quickly as possible. Bolting can be prevented by either planting early in the spring so that bolt-prone plants grow during late spring before the summer heat, or planting late in the summer so most of the growth is during the cooler early fall. Strategies to help prevent bolting include mulching with organic mulches and watering regularly in order to keep the soil temperature down. Cultivars within each crop vary as to their susceptibility to bolting, so planting less susceptible cultivars is also a good strategy.

Many trials evaluating four Brassica species have been conducted at the Experiment Station beginning in 1985. Broccoli trials were conducted 1985-1987, 1993-1995, and 2000-2002 (Hill 1986, 1987, 1988, 1989, 1995, 1996, and 2003). Cauliflower trials were conducted 1986-1988 and 1993-1995 (Hill 1987, 1988, 1989, 1995, and 1996). Chinese cabbage and Pak Choi trials were conducted 1988-1990 (Hill 1990 and 1991). In the intervening years since these trials, many of the tested cultivars are no longer available and many new cultivars have been introduced. So trials were conducted for cauliflower in 2004-2006, Chinese cabbage 2007-2008, Pak choi 2009-2011, and broccoli 2012-2014. This is a summary of the results.

METHODS AND MATERIALS

Sites and soils. All trials were conducted at the Valley Laboratory in Windsor, CT on Merrimac sandy loam (Entic Haplorthod), an inland sandy terrace soil with somewhat limited moisture holding capacity (Shearin and Hill 1962); and at Lockwood Farm in Hamden, CT on Cheshire fine sandy loam (Typic Dystrochrept), a coastal loamy upland soil with moderate moisture holding capacity (Reynolds 1979).

Cultivars. Twenty-four cultivars of cauliflower were grown at both Windsor and Hamden in the spring and fall of 2004, both sites in the spring of 2005, Windsor only in the fall of 2005, and at both sites in the spring of 2006 (9 trials total). Freedom, Minuteman, Ravella, and Snow Grace were planted in all 9 trials. Attribute and White Passion were planted in 8 trials, Absolute and Wentworth in 7 trials, Brilljans, Cumberland, and First White in 6 trials, Apex, Early Dawn, Early White, Majestic, and Symphony in 4 trials, Artica and Baldo in 3 trials, Cassius, Phoenix, Silver Cup, and Snow Mystique in 2 trials, and Cheddar and Pavilion in 1 trial.

Fourteen cultivars of Chinese Cabbage were grown at both Windsor and Hamden in the spring and fall of 2007 and 2008 (8 trials total). Blues, Minuet, Nikko, Optiko, and Taranko were planted in all 8

trials. Greenwich, Rubicon and Yuki were planted in 6 trials, and Apollo, Bilko, Jazz, Mirako, Monument, and T652 were planted in 4 trials.

Thirteen cultivars of pak choi were grown at both Windsor and Hamden in the spring and fall of 2009, in the spring of 2010, at Hamden only on the fall of 2010, and at both sites in the spring of 2011 for a total of 9 trials. Black Summer, Fuyu Shomi, Joi Choi, Mei Qing Choi, and Win Win Choi were grown in all 9 trials. Canton Long was grown in 5 trials, Bonsai in 4 trials, and All Seasons, Canton Short, Dwarf Green, Green Boy, Summer Boy, and Summer Flavor in 3 trials.

Twelve cultivars of broccoli were grown in the spring of 2012, 2013, and 2014. Trials were conducted at both Windsor and Hamden in 2012 and 2013 and at Windsor only in 2014. Nine cultivars were grown all three years (Avenger, Bay Meadows, Blue Wind, Castle Dome, Coronado, Diplomat, Emerald Jewel, Gypsy, and Imperial). Concord was grown in 2012 and 2014, Ironman in 2013, and Maximo in 2014.

Culture. Seedlings of all species were grown in Promix BX (Premier, Red Hill PA) in standard plastic pots (3601 insert) measuring $2\frac{5}{8}$ X $2\frac{1}{4}$ X $2\frac{5}{8}$ inches (volume 15.5 cubic inches). After germination, plants were thinned to one per pot. The seedlings were fertilized with water soluble 20-20-20 (N-P₂O₅-K₂O) (0.5 oz/gal) four weeks after germination. Field spacing of all species was 1.5 feet within the row with rows 3 feet apart (9680 plants/A). There were 30 plants per cultivar, with 5 reps of 6 plants per cultivar.

Cauliflower was seeded in the greenhouse for the spring crop on March 13, 2004, April 1, 2005, and April 2, 2006. For the fall crops, cauliflower was seeded in the greenhouse on June 28, 2004 and June 30, 2005. After hardening the plants in a cold frame, they were transplanted between May 4 and May 14 for the spring crop at both sites. Fall plantings were transplanted in the field August 2 and 3. As heads began to form in both spring and fall, the outer leaves were tied above the head so that light was excluded and the head would remain white.

Chinese cabbage was seeded in the greenhouse for the spring crop on March 21, 2007 and March 24, 2008. For the fall crops, Chinese cabbage was seeded in the greenhouse on June 21, 2007 and June 22, 2008. After hardening the plants in a cold frame, they were transplanted between May 7 and May 12 for the spring crop at both sites. Fall plantings were transplanted in the field July 25 and July 26.

Pak choi was seeded in the greenhouse for the spring crop on March 30, 2009, March 31, 2010, and March 31, 2011. For the fall crops, pak choi was seeded in the greenhouse on July 13, 2009 and July 14, 2010. After hardening the plants in a cold frame, they were transplanted between May 5 and May 15 for the spring crop at both sites. Fall plantings were transplanted in the field July 27 and July 28.

Broccoli was seeded in the greenhouse for the spring crop on March 12, 2012, March 27, 2013, and March 27, 2014. After hardening the plants in a cold frame, they were transplanted between April 30 and May 15 at both sites.

General information for all crops. The field soils were fertilized just before transplanting each year with commercial grade 10-10-10 (N-P₂O₅-K₂O) material at 1300 lb/A, a rate determined from analysis of soil from both sites before the experiment. Different experimental fields at each location were used each year to minimize potential disease buildup. Weeds were controlled by hand cultivation between plants and mechanically by rototilling between rows. Overhead irrigation was used at both sites to ensure that plants received at least 1 inch of water per week either through rainfall or irrigation. Plants were removed from all plots at the end of the growing season and fields fallowed over winter.

Statistical Analysis. A three-factor (cultivar, site, year) analysis of variance (ANOVA) was used to compare the yields. When appropriate, a four-factor (cultivar, site, year, season) ANOVA was used to compare the yields. Tukey's HSD test was used to test for significant differences between cultivar yields at $p < 0.05$.

RESULTS AND DISCUSSION

Of the twenty-four cultivars of cauliflower, Freedom produced the greatest yields in both spring and fall with a combined yield of 11.6 T/A (Table 1) with Attribute and Minuteman each having an average yield of 9.8 T/A. Freedom and Attribute averaged high yields equally in both seasons while Attribute was very strong as a fall crop but weaker as a spring crop. Other cultivars averaging with at least 8 T/A combining both seasons were Majestic (8.2 T/A) and Brilljans (8.0 T/A). In the spring, Freedom yields (11.0 T/A) was statistically equal to Attribute (10.4 T/A), Wentworth (9.6 T/A), Symphony (8.6 T/A), Cumberland (8.4 T/A), Absolute (8.1 T/A), and White Passion (7.8 T/A). Many of these strong spring cultivars did poorly in the fall plantings by failing to form marketable heads. These included Wentworth (1.2 T/A), Cumberland (1.1 T/A), and Absolute (0.6 T/A). The highest yielding fall cultivars were Freedom (12.1 T/A), Minuteman (12.0 T/A), Majestic (9.8 T/A), Snow Grace (9.6 T/A), Attribute (9.3 T/A), and First White (9.0 T/A).

As the heads formed for most cultivars, the outer leaves were tied to prevent light from reaching the head. Some cultivars, however, were self blanchers where leaves surrounding the head curled around the developing head protecting it from the light. This is a valuable quality for a cultivar because it saves on the hand labor of tying each plant. Cultivars that were good self blanchers and produced consistently high quality heads included Cumberland, Freedom, Minuteman, Ravella, Symphony, White Passion, and Wentworth. Cultivars with poor quality heads included Baldo (variable quality), Early White (fuzzy heads and leafy), First White (generally poor quality), Phoenix (pink heads), and Snow Grace (heads variable).

Chinese cabbage yields were greater at Windsor than Hamden, 13.8 and 12.1 T/A respectively (Table 2); and greater in 2007 (16.3 T/A) than in 2008 (13.3 T/A). Spring yields over both years was highest for Bilko (19.2 T/A) which were greater than for Yuki (8.3 T/A), Taranko (11.4 T/A), Jazz (3.2 T/A) Apollo (0 T/A), and Monument (3.1 T/A). Yuki (21.9 T/A) averaged the higher yields for fall plantings which were significantly greater than for Rubicon (12.9 T/A), Greenwich (10.2 T/A), Minuet (11.6 T/A), T652 (11.0 T/A), and Monument (10.5 T/A). Combining both plantings, Bilko had the greatest yields (19.4 T/A). Overall, the fall planting averaged the greatest yields (14.3 T/A) compared to the spring planting (11.6 T/A). The lower yields in the spring were partly due to bolting of several cultivars in the spring which led to decreased yields. Cultivars with the greatest amount of bolting included Yuki, Taranko, Jazz, Apollo, and Monument. Taranko produced excellent quality heads in the spring of 2007, but bolted in the spring of 2008. The other low yielding cultivars bolted in the spring of both years.

Of the 13 pak choi cultivars, only six did not bolt in the spring and produced a marketable product. Spring Joi choi yields (23.3 T/A) were almost double the yields of the other cultivars that did not bolt (Table 3). Win Win choi (13.4 T/A) had the greatest fall yields and was statistically equal to Joi choi (12.7 T/A), Black Summer (10.6 T/A), and Fuyu Shomi (9.6 T/A). Although they bolted in the spring, Bonsai (10.3 T/A), Summer Flavor (9.9 T/A), and Canton Short (9.5 T/A), produced strong yields in fall plantings. Averaging both seasons, Joi Choi produced the greatest yields (18.0 T/A). The quality of all the cultivars that did not bolt was consistently excellent.

Spring broccoli yields differed among years from 6.3 T/A in 2012, to 5.3 T/A in 2014, and only 2.4 T/A in 2013 (Table 4). Nine of the cultivars were grown all 3 years, one cultivar for 2 years, and two for 1 year. Of the cultivars grown for 3 years, Avenger and Imperial (5.3 T/A) along with Gypsy and

Diplomat (4.8 T/A) had yields greater than for Emerald Jewel (3.9 T/A) and Blue Wind and Castle Dome (3.9 T/A). When comparing all cultivars, Maximo had the greatest yields (6.8 T/A) and Ironman had the smallest yields (2.4 T/A), but both cultivars were only grown for one year so there was no statistical analysis with these cultivars. Cultivars with the best quality heads included Avenger, Diplomat, Bay Meadows, and Blue Wind. Maximo, Concord, and Emerald Green produced poor quality heads that were leafy and uneven.

SUMMARY

Here are cultivar suggestions for each crop and what cultivars to avoid, taking into consideration both yield and crop quality.

- Cauliflower (spring)* – Freedom, Attribute, Wentworth, Cumberland
 Avoid – Early White, Baldo, Phoenix, First White
- Cauliflower (fall)* – Freedom, Minuteman, Majestic
 Avoid – Wentworth, Cumberland, Phoenix, Absolute, Attribute
- Cauliflower (both seasons)* – Freedom, Attribute, Minuteman
 Avoid – Baldo, Phoenix, Snow Grace, First White, Early White
- Chinese Cabbage (spring)* – Bilko, Nikko, Rubicon
 Avoid (due to bolting) – Yuki, Taranko, Jazz, Apollo, Monument
- Chinese Cabbage (fall)* – Bilko, Yuki, Jazz, Nikko
 Avoid – Monument, Greenwich, Minuet
- Chinese Cabbage (both seasons)* – Bilko, Blues, Nikko
 Avoid – Monument, Apollo, Jazz
- Pak Choi (spring)* – Joi Choi, Fuyu Shomi
 Avoid (due to bolting at least one spring) – All Seasons, Bonsai, Canton Short, Dwarf Green, Green Boy, Mei Qing Choi, Summer Flavor, Summer Boy
- Pak Choi (fall)* – Win Win Choi, Joi Choi, Black Summer, Fuyu Shomi, Bonsai
 Avoid – Dwarf Green, All Seasons
- Pak Choi (both seasons)* – Joi Choi, Win Win Choi, Fuyu Shomi
 Avoid – All Seasons, Bonsai, Canton Short, Dwarf Green, Green Boy, Summer Flavor, Summer Boy
- Spring Broccoli* – Imperial, Avenger, Diplomat, Bay Meadows, Blue Wind
 Avoid – Maximo, Concord, Coronado, Emerald Jewel

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Table 1. Average yield of cauliflower (T/A) assuming 9680 plants/A. Seasonal yields of cultivars with same letter within a column were not significantly different at $P \leq 0.05$ using Tukey HSD. Cultivars trialed for only one season are excluded.

Cultivar	Spring	Fall	Average
Freedom	11.0 a	12.1 a	11.6
Attribute	10.4 ab	9.3 ab	9.8
Wentworth	9.6 abc	1.2 f	5.4
Symphony	8.6 abcd	4.5 de	6.0
Cumberland	8.4 abcd	1.1 f	4.8
Absolute	8.1 abcd	0.6 f	4.4
White Passion	7.8 abcd	4.8 de	6.3
Apex	7.5 bcd	2.4 ef	5.6
Minuteman	7.5 bcd	12.0 a	9.8
Phoenix	7.4 bcde	0.0 f	3.7
Briljans	7.1 bcdef	8.8 ab	8.0
Ravella	7.0 cdef	8.5 bc	7.8
Majestic	6.6 cdef	9.8 ab	8.2
Snow Grace	6.2 cdef	9.6 ab	7.9
Early Dawn	5.8 def	8.6 bc	7.6
Attribute	5.2 def	0.6 f	2.9
First White	5.2 def	9.0 ab	7.1
Early White	4.1 ef	7.2 bcd	5.6
Baldo	3.9 f	5.4 cde	4.6
Combined	7.2 a	6.1 b	6.7

Table 2. Average yield of Chinese cabbage (T/A) assuming 9680 plants per acre. Seasonal yields of cultivars with same letter within a column were not significantly different at $P \leq 0.05$ using Tukey HSD.

Cultivar	Spring	Fall	Combined
Bilko	19.2 a	19.6 ab	19.4
Blues	16.1 ab	16.1 abc	16.1
Nikko	16.6 ab	15.2 abc	15.9
Optiko	15.2 ab	15.2 abc	15.2
Yuki	8.3 cde	21.9 a	15.1 *
Rubicon	14.4 ab	12.9 bc	13.6
Taranko	11.4 bcd	14.9 abc	13.1
Mirako	11.6 abcd	14.2 abc	12.9
Greenwich	14.1 abc	10.2 c	12.1
Minuet	12.1 abc	11.6 c	11.8
T652	11.9 abcd	11.0 c	11.5
Jazz	3.2 def	17.3 abc	10.3 *
Apollo	0.0 f	15.3 abc	7.6 *
Monument	3.1 ef	10.5 c	6.8
Combined	11.6 b	14.3 a	12.9
	<u>Windsor</u>	<u>Lockwood</u>	
Location	13.8 a	12.1 b	

* Cultivars with yields that differed significantly between seasons

Table 3. Average yield of pak choi (T/A) assuming 9680 plants per acre. Seasonal yields of cultivars with same letter within a column were not significantly different at $P \leq 0.05$ using Tukey HSD. Seasonal comparison statistics were not run for cultivars with no saleable heads in spring.

Cultivar	Spring	Fall	Combined
Joi choi	23.3 a	12.7 a	18.0
Fuyu Shomi	12.1 b	9.6 ab	10.8
Black Summer	9.4 b	10.6 ab	10.0
Win Win Choi	8.8 bc	13.4 a	11.1
Canton Long	4.4 cd	7.8 b	6.1
Mei Qing Choi	3.5 d	7.6 b	5.6
All Seasons	*	6.0	
Bonsai	*	10.3	
Canton Short	*	9.5	
Dwarf Green	*	2.8	
Green Boy	*	7.4	
Summer Flavor	*	9.9	
<u>Summer Boy</u>	*	9.2	
Combined *	10.2 a	9.0 a	

* Cultivars produced no yields due to bolting.

Table 4. Average yield (T/A) of spring broccoli grown Hamden and Windsor CT assuming 9680 plants/A. Yields of cultivars with same letter were not significantly different at $P \leq 0.05$ using Tukey HSD.

Cultivar	Year			All
	2012	2013	2014	Years
Maximo*	-	-	6.8	6.8
Imperial	7.3	2.9	6.3	5.5 a
Avenger	6.8	3.3	6.3	5.5 a
Gypsy	7.3	2.4	5.3	5.0 a
Diplomat	6.8	3.3	4.4	4.8 a
Bay Meadows	5.8	2.9	5.3	4.7 ab
Concord*	5.8	-	1.9	3.8
Coronado	6.3	2.4	3.9	4.2 ab
Emerald Jewel	5.3	2.4	4.8	4.2 bc
Blue Wind	4.8	1.9	5.8	4.2 c
Castle Dome	4.8	1.9	5.3	4.0 c
Ironman*	-	2.4	-	2.4
Combined	6.1 a	2.6 c	5.1 b	4.6

*Lack of replication precluded statistical analysis; presented for comparison only



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