Hybridizing Collard and Cabbage May Provide a Means to Develop Collard Cultivars

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Abstract. Collard (*Brassica oleracea* L. Acephala Group) is a leafy green vegetable adapted to the southeastern United States. The number of commercially available collard cultivars is limited, and the most popular cultivars are susceptible to fusarium yellows, a disease that most cabbage (*B. oleracea* Capitata group) cultivars are resistant to. We hypothesized that hybrids of cabbage and collard would look more like collard, because heading of cabbage is at least partially recessive to the nonheading growth habit of collard. We also postulated that cabbage–collard hybrids might be used directly as collard cultivars. To test these postulates, cytoplasmic male sterile cabbage inbreds were crossed to different male fertile collard inbreds and hybrid seed was produced. Resulting cabbage–collard hybrids were compared to conventional collard cultivars in three replicated field trials in South Carolina. In all trials, cabbage–collard hybrids exhibited size and weight more similar to conventional collard than cabbage, and throughout most of the growing season the collards remained nonheading. In addition, the cabbage–collard hybrids were much more uniform than open-pollinated collard cultivars. Among cabbage–collard hybrids there was significant variation with some hybrids appearing more collard-like than others. The collard inbreds designated A and B may have the greatest potential for making promising cabbage–collard hybrids. Particular hybrids (i.e., A₃ or B₂), derived from these inbreds and tested in this study, can perform better than certain conventional collards and may serve as possible new cultivars of this vegetable crop.

Collard (*Brassica oleracea* L. Acephala Group) is a uniquely American cole crop adapted to the southeastern United States. Results of at least two previous genetic marker studies (Farnham, 1996; Song et al., 1988) indicate that the likely closest relative to collard is heading cabbage (*B. oleracea* Capitata Group). Although collard is traditionally grouped with the kale in the Acephala group, Farnham (1996) suggested that collard might be more appropriately grouped with cabbage (Capitata Group). Several lines of anecdotal evidence support this theory. First, collard and cabbage have been grown in close proximity in the southeastern U.S. for at least 200 years

(Betts, 1999; Hazzard, 1831). Kale, except as a garden vegetable, is a relatively new crop in this region. Secondly, there are landraces of collard grown by seed savers throughout North and South Carolina that are generically called cabbage collard (Farnham, 1996). These landraces look more like collard than cabbage, but they have a propensity to form a loose head as plants reach harvest size or become over-mature.

Current collard cultivars fall into two categories. Although they are used less and less, some producers still grow open-pollinated (OP) populations as cultivars. These OP collard cultivars, exemplified by ‘Champion’ or ‘Vates’, tend to be variable for many characteristics. There has been a tendency to move away from these populations in favor of growing F₁ hybrids such as ‘Blue Max’ or ‘Top Bunch’. This shift towards hybrids has occurred primarily so producers can attain more uniformity of harvest typically expressed by the hybrids. One advantage of OP cultivars over hybrids is that seed cost is a fraction of that for hybrids. This seed cost advantage and particular traits

of certain OP cultivars, for instance, a tendency of ‘Champion’ to resist bolting under winter conditions (Farnham and Garrett, 1996), have provided a reason for these older cultivars to persist in spite of the advantages commercial hybrids provide.

Today, the numbers of commercially available OP and hybrid collard cultivars are both limited. Nearly all cultivars tend to be susceptible to diseases such as fusarium yellows (Farnham et al. 2001), whereas most cabbage cultivars are highly resistant (Dixon, 1981). Such disease susceptibility makes most collard cultivars vulnerable to severe damage when grown in infested soil under warm conditions (Farnham et al., 2001).

Previously, it was reported that heading of cabbage is partially recessive to the nonheading nature expressed by collard (Dickson and Wallace, 1986). Thus, we hypothesized that hybrids between cabbage and collard would look more like collard than cabbage and that hybridizing between the crop groups might provide a means to develop new collard cultivars. Such hybrids could exploit the especially large pool of cabbage germplasm available in the United States and throughout the world. Making these cabbage–collard hybrids might also provide a strategy for incorporating disease resistances from cabbage. Thus, the primary objectives of this study were to synthesize cabbage–collard hybrids and to compare them to conventional collard cultivars in the field to assess their potential as future collard cultivars.

Materials and Methods

Plant materials. Materials used in this study included conventional cultivars of collard and cabbage obtained through commercial sources as well as a set of cabbage-by-collard hybrids developed specifically for this work. Conventional collard cultivars used in all field trials included the open-pollinated cultivars Champion, Vates, and Morris Heading all obtained from the Alf Christianson Co. (Mt Vernon, Wash.), and the F₁ hybrid cultivars Blue Max, Top Bunch, Flash, and Heavicrop obtained from Abbott and Cobb (Feasterville, Pa.). Three hybrid cabbage cultivars including Blue Vantage, Bravo and Pacifica were also grown as checks in the trials.

Cabbage–collard hybrids were made using a cytoplasmic male sterile (CMS) cabbage as the female and a collard inbred as a fertile male. A total of 12 CMS cabbage inbreds and four fertile collard inbreds were used to make the hybrids. The cabbage inbreds (designated Cab₁ through Cab₁₂) were relatively advanced inbreds from the North American cabbage breeding program of Asgrow. All of these inbreds expressed fusarium yellows resistance and some expressed intermediate resistance to black rot. These cabbage inbreds differed for many horticultural traits. The four collard inbreds were developed by the USDA–ARS–U.S. Vegetable Laboratory cole crop breeding program and included two conventional F₅ inbreds (designated A and B) derived from the hybrids ‘Heavicrop’ and ‘Top Bunch’, respectively, one double haploid (designated C) derived from a selection of

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the OP cultivar Champion, and one S_4 inbred (designated D) derived by selfing a selection from a South Carolina landrace of collard. The conventional collard inbreds were developed using a standard pedigree selection scheme for good horticultural phenotype and leaf characteristics similar to that described for cabbage (Dickson and Wallace, 1986). This scheme includes a cold treatment (e.g., vernalization), which is required to bring about flowering and to facilitate self-pollinations.

Cabbage-collard hybrids were synthesized in field cages during the winter and spring of 1999 at Asgrow facilities in San Juan Bautista, Calif. Four hybrids were made in a single cage by including a single row each of four different CMS cabbage inbreds and two rows of one of the fertile collard inbreds (i.e., the only source of fertile pollen in a cage) in the center of the cage. At flowering, bees were introduced into each cage and allowed to pollinate flowers. Upon maturation of seed, plants from each single CMS row were harvested separately; seed was threshed from pods and then maintained as an individual hybrid seed lot. The hybrids were designated as follows: $A_1 = \text{Cab}_1 \times A$; $A_2 = \text{Cab}_4 \times A$; $A_3 = \text{Cab}_5 \times A$; $A_4 = \text{Cab}_8 \times A$; $B_1 = \text{Cab}_1 \times B$; $B_2 = \text{Cab}_6 \times B$; $B_3 = \text{Cab}_7 \times B$; $B_4 = \text{Cab}_2 \times B$; $C_1 = \text{Cab}_8 \times C$; $C_2 = \text{Cab}_{11} \times C$; $C_3 = \text{Cab}_{12} \times C$; $C_4 = \text{Cab}_3 \times C$; $D_1 = \text{Cab}_9 \times D$; $D_2 = \text{Cab}_{10} \times D$; $D_3 = \text{Cab}_2 \times D$; $D_4 = \text{Cab}_3 \times D$. A larger set of cabbage inbreds than four was used to maximize the number and variation of actual cabbage-collard genotypes that we could evaluate. Since we could only place one fertile collard inbred in each cage, this limited the number of collard lines that could be included. In total, 16 hybrids were generated for testing. The four hybrids made with one collard male represent a single half-sib family.

Field trials. Cabbage-collard hybrids were tested in three field trials conducted in South Carolina. Two of the trials were conducted in Charleston; one in Fall 1999 and the other in Fall 2000. A third trial was conducted in Lexington in Spring 2000. In the first trial in 1999, 'Heavycrop' and the cabbage-collard hybrids A_4 , B_4 , C_4 , and D_4 were not tested, but all entries described in the previous section were included in the subsequent trials in 2000. For each trial, entries were seeded to 200-cell trays (Speedling Inc., Sun City, Fla.) filled with Metromix 360 (Grace Sierra, Milpitas Calif.) 4 to 5 weeks before transplanting. Seedlings were grown in a greenhouse until four days before transplanting, then placed outside, allowing them to harden off. During seedling development, trays were watered as needed. Transplanting dates for the three trials were 1 Sept. 1999 (Charleston), 8 March 2000 (Lexington), and 15 Sept. 2000 (Charleston). The soil type at Lexington was a Troup sand and at Charleston was a Yonges loamy sand.

The field plot design for all three trials was a randomized complete block. Each study included four blocks (or full replications) that included plots of every entry indicated above, except that in Fall 1999 at Charleston only two blocks were included. Each plot consisted of about 30 to 35 plants of a given entry spaced

0.3 m apart within rows. Row spacing was 1.02 m at Charleston and 0.97 m at Lexington. Collards were grown on the flat at Lexington where the sand drains rapidly and on raised beds at Charleston where soils drain much more slowly. All cultural practices (e.g., cultivation, fertilization, and insect control) were based on commercial standards for the areas (Johnson et al., 1987). Supplemental water was applied to all trials via overhead irrigation as needed.

Plant growth was monitored throughout the growing season in each environment and as maturity approached, the number of leaves was counted. When a majority of collard and cabbage-collard hybrids attained a stage with about 22 to 24 leaves, a harvest date for each environment was chosen for evaluating all entries. Specifically, plants were harvested 19 Nov. 1999, 23 May 2000, and 21 Nov. 2000 for the three respective trials. Just before harvest, a representative section of each plot that included six plants (= 1.8 m) was marked for harvest. At this time, the entire plot was evaluated for plant uniformity and heading habit, using different 1 to 5 scales. For plant uniformity, which was evaluated largely based on leaf characteristics, plant size, habit, and color, 1 = a high degree of uniformity among plants, 2 = mostly uniform plants with slight variation, 3 = significant variation at least among a few of the plants, 4 = a high degree of variation among the plants, and 5 = extreme variation among plants with almost no two plants alike in a plot. For head habit 1 = nonheading like the standard collard cultivar 'Top Bunch', 2 = mostly nonheading with a slight cupping of the terminal leaves (e.g., like the collard cultivar 'Blue Max'), 3 = more definitive cupping of

terminal leaves, 4 = cupping that results in a small, loose, cabbage-like head, and 5 = heading similar to the check cabbage cultivars. Before plants were cut, plant height and width were measured for all plants included in the designated harvest sample. On each harvest date, all plants slated for harvest in all plots were cut at the soil surface and weighed.

Statistical analysis. All analyses of variance were performed with Proc GLM of SAS (SAS Institute, Cary, N.C.). Trials from the three different environments were analyzed separately to evaluate trait differences among genotypes grown in the respective environments. Genotype means were compared using Fisher's protected LSD. An analysis combining results for 21 entries grown in all three environments was also conducted to assess potential environmental and genotype by environment effects. Single degree of freedom contrasts were used to compare trait expression of collard-cabbage half-sib hybrid families to expression of OP collard cultivars, hybrid collard cultivars, and cabbage cultivars.

Results and Discussion

Results of the three field trials were very comparable in that individual genotypes exhibited similar appearance and performance across all environments. Results from fall 2000 at Charleston are presented (Table 1) as very representative of the other two trials. The combined characteristics of height, width, and head habit at maturity show collard to exhibit a height of about 54 to 58 cm, width of about 86 to 95 cm, and a head habit rating between 1 and 2 with most rated as 1 or nonheading.

Table 1. Trait means for fresh weight, height, width, head habit, and uniformity of hybrid and open-pollinated (OP) collard cultivars, cabbage cultivars, and experimental cabbage-collard hybrids grown in Fall 2000 at Charleston, S.C.

Entry type	Entry	Fresh wt (kg)	Ht (cm)	Width (cm)	Head habit (rating) ^z	Uniformity (rating) ^z
F ₁ collard	Blue Max	1.27	58.3	94.8	2.0	1.5
	Top Bunch	1.23	58.5	87.0	1.0	1.8
	Flash	1.28	57.8	94.5	1.0	1.5
	Heavycrop	1.09	57.3	94.3	1.0	1.5
OP collard	Champion	1.03	54.0	87.3	1.5	3.3
	Vates	1.01	57.3	86.0	1.0	4.0
	Morris Heading	1.08	57.3	95.3	1.3	4.0
F ₁ cabbage-collard	Hybrid A ₁	0.95	45.8	86.8	2.0	1.8
	Hybrid A ₂	1.12	52.8	91.0	1.8	1.8
	Hybrid A ₃	1.13	55.8	93.3	2.0	1.3
	Hybrid A ₄	0.97	53.8	88.0	2.0	1.3
F ₁ cabbage-collard	Hybrid B ₁	1.06	44.8	85.5	2.0	2.3
	Hybrid B ₂	1.21	52.3	92.8	1.8	1.8
	Hybrid B ₃	1.01	50.0	90.5	1.5	1.5
	Hybrid B ₄	1.12	50.5	91.8	2.0	1.8
F ₁ cabbage-collard	Hybrid C ₁	1.15	51.0	87.3	2.0	1.5
	Hybrid C ₂	1.29	49.5	84.0	2.0	2.3
	Hybrid C ₃	1.28	49.5	83.8	3.0	1.5
	Hybrid C ₄	1.18	48.5	87.5	2.0	2.0
F ₁ cabbage-collard	Hybrid D ₁	1.18	49.8	90.3	2.0	1.5
	Hybrid D ₂	1.34	55.8	96.8	2.0	1.8
	Hybrid D ₃	1.33	55.5	100.8	2.0	1.8
	Hybrid D ₄	1.26	53.5	88.0	2.0	1.3
F ₁ cabbage	Blue Vantage	1.38	40.5	76.3	5.0	2.3
	Bravo	1.25	40.5	73.5	5.0	1.8
	Pacifica	1.48	32.0	64.5	5.0	2.5
LSD _{0.05}		0.27	4.6	6.9	0.5	0.8

^zHead habit and uniformity are evaluated using two different 1 to 5 rating scales.

Table 2. Mean squares from the analysis of variance of plant fresh weight, height, width, heading habit, and uniformity of collard (6), cabbage-collard (12), and cabbage (3) genotypes (G) grown in three environments (E).

Source	df	Mean squares				
		Fresh wt (kg)	Ht (cm)	Width (cm)	Head habit rating (1-5)	Uniformity rating (1-5)
E	2	2.731**	5408.2**	6638.4**	2.32**	12.25**
Rep (E)	7	0.067*	53.4**	68.7*	0.10	0.20
G	20	0.104**	348.0**	654.3**	13.41**	6.28**
G × E	40	0.022	15.7	37.4	0.33**	0.81
Error	140	0.029	11.1	25.9	0.10	0.30
Total	209					

***Significant at $P \leq 0.05$ or 0.01, respectively.

Table 3. Trait means of experimental cabbage-collard half-sib hybrid families compared to those of F_1 collard cultivars, OP collard cultivars, and F_1 cabbage cultivars across three environments in South Carolina.

Trait	Cabbage × A	Cabbage × B	Cabbage × C	Cabbage × D
Fresh wt (kg/plant)	0.92 ^z	0.98	1.06	1.12
F_1 collard cultivars	1.05*	1.05	1.05	1.05
OP collard cultivars	0.90	0.90	0.90*	0.90*
Cabbage cultivars	1.20*	1.20*	1.20*	1.20*
Height (cm)	43.9	40.9	42.3	46.4
F_1 collard cultivars	49.4*	49.4*	49.4*	49.4*
OP collard cultivars	47.9*	47.9*	47.9*	47.9
Cabbage cultivars	31.1*	31.1*	31.1*	31.1*
Width (cm)	80.2	80.4	77.3	85.2
F_1 collard cultivars	81.7	81.7	81.7*	81.7
OP collard cultivars	81.2	81.2	81.2*	81.2*
Cabbage cultivars	60.0*	60.0*	60.0*	60.0*
Head habit (rating)	1.9	2.0	2.7	2.2
F_1 collard cultivars	1.3*	1.3*	1.3*	1.3*
OP collard cultivars	1.2*	1.2*	1.2*	1.2*
Cabbage cultivars	5.0*	5.0*	5.0*	5.0*
Uniformity (rating)	1.9	2.1	2.0	2.1
F_1 collard cultivars	2.0	2.0	2.0	2.0
OP collard cultivars	4.3*	4.3*	4.3*	4.3*
Cabbage cultivars	2.4*	2.4	2.4	2.4

^zThis is the combined mean for three hybrids making up a half-sib family across the three test environments.

*Indicates that the mean is significantly ($p < 0.05$) different than the mean for the half-sib cabbage-collard hybrid family as determined by single degree of freedom contrasts.

The superiority of hybrid collard cultivars over conventional OP collard cultivars is demonstrated by greater heights and widths, as well as by greater fresh weights per plant and a higher degree of cultivar uniformity for the former (Table 1). In general, the check cabbage hybrids are much shorter (32 to 40 cm) than all collard cultivars. The cabbage cultivars also exhibit a smaller width (64 to 76 cm) and have a head habit of 5 (i.e., fully heading).

Trait expression among the cabbage-collard hybrids was intermediate between collard and cabbage means, but the overall appearance of most of the experimental hybrids was consistent and a majority are best characterized as more collard-like than cabbage-like. Test hybrid heights were all greater than cabbage heights and all but one were significantly greater than the tallest cabbage (Table 1). Four cabbage-collard hybrids were not shorter than the tallest collard cultivars that attained a height of about 58 cm, and thirteen out of sixteen test hybrids were not shorter than the shortest collard 'Champion' that measured 54 cm tall.

As with height, mean widths of cabbage-collard hybrids also tended to be intermediate when compared to means for collard and cabbage checks (Table 1). However, a greater number of the test hybrids (10 in all) with widths of 88 cm or more were not significantly

different from most collard cultivars.

Head habit is a critical characteristic of any cabbage-collard hybrid. If a hybrid heads to a significant degree, it loses value as a potential collard cultivar because collard leaves are typically marketed in loose bunches, not as heads. As with the above traits, the test hybrids were intermediate between collard and cabbage genotypes but most were more like collard than cabbage. Cabbage genotypes began to cup and form a head relatively early in development. The test cabbage-collard hybrids remained nonheading for most of the season, but they began to cup, and in at least one case began to form small heads, just before harvest when they were rated. The popular collard hybrid 'Blue Max' normally is rated a 2.0 for head habit, because it exhibits slight cupping of the terminal leaves. The OP cultivars 'Champion' and 'Morris Heading' had head habit ratings between 1.0 and 2.0 because they contained plants that exhibit some cupping. Most of the test hybrids were given the same rating as 'Blue Max', but three had ratings <2.0, indicating they were nearly nonheading. These observations generally agree with a previous suggestion that heading of cabbage is partially recessive to the nonheading characteristic of collard (Dickson and Wallace, 1986).

Fresh weights of only two of sixteen cab-

bage-collard test hybrids grown in Fall 2000 were lower than the three heaviest collard hybrids that ranged in weight from 1.23 to 1.28 kg (Table 1). None of the test hybrids had significantly lower fresh weights than any OP collard cultivar, and in several instances the test hybrids had significantly greater plant yield than the OPs. The test hybrids also had a much better crop uniformity rating (i.e., usually <2) than the OP cultivars that were typically rated 3 or higher. Uniformity of the CMS cabbage-collard hybrids was very similar to that of the collard hybrid cultivars (all known to be fertile and likely made using a conventional self incompatibility system), indicating that this important characteristic will not limit the potential usefulness of any of these experimental hybrids.

Analysis of variance of the combined data from the three test environments indicated that environmental and genotypic factors account for the greatest share of variation in expression of all measured traits (Table 2). With all characters, these two effects were significant. A significant genotype by environment interaction was only observed for the head habit rating; for all other traits, the interaction was not significant. This observation underscores the fact that the relative performance of genotypes across environments was consistent. In other words, although mean height or weight varied between environments, the relative ranking of genotype trait means among environments did not vary significantly. The significant interaction effect observed for heading habit is probably explained by an increased propensity of some cabbage-collard hybrids to exhibit more definitive cupping of leaves in one environment and not in another.

We deemed it important to evaluate whether certain half-sib cabbage-collard hybrid families were more collard-like than others to determine if hybrids made using particular collard inbreds might tend to make more collard-like hybrids than those made using others. Overall, contrasts between trait expression of half-sib families and hybrid or OP collard cultivar groups varied when evaluated across all three environments (Table 3). The half-sib family made using collard inbred D exhibited means for fresh weight, height and width that were nearly equal to or that exceeded those of the hybrid and OP collard cultivars. This same family exhibited some cupping of leaves and had a mean heading habit of 2.2. In addition, it exhibited uniformity similar to hybrid collards and much better than the OPs. Crosses made using collard inbred C as the fertile parent had a mean fresh weight similar to collard cultivars, but it was shorter, had smaller plant width, and exhibited the highest propensity of all families to form heads (e.g., mean rating of 2.7). The other two half-sib families derived from the A and B collard parents were similar to collard cultivars for fresh weight and width, were smaller in height, and had relatively lower heading habit ratings than the other two families. Based on these observations, it may be more likely to develop a collard cultivar from a cabbage by collard cross using one collard inbred (i.e., possibly D) over another (i.e., C).

Considering the breadth of collard germplasm (Farnham, 1996) and even greater diversity in cabbage germplasm pools (Dickson and Wallace, 1986) that is available, the actual number of different collard by cabbage hybrids that it is possible to make is very great. In this study, a relatively small number (16) of cabbage by collard crosses were evaluated to determine if any such cross might have potential as a collard cultivar. If even one hybrid out of the 16 evaluated approached the standards necessary to be grown as a collard cultivar, it would appear the likelihood is good for using this method to successfully develop collard cultivars. Results from three environments indicate that at least two cabbage–collard hybrids, A₂ and B₂, tested herein (Table 1) exhibited good potential as collard cultivars. These two hybrids have similar size, mass, and uniformity as the collard hybrid checks and have relatively low propensity to head.

To our knowledge, this is the first formal publication suggesting that hybridizing cabbage and collard may provide a novel approach

for developing new collard cultivars. This method exploits the relatively close relationship known to exist between cabbage and collard (Farnham, 1996; Song et al., 1988). Although it is uncertain what the exact response of these hybrids in infested soil might be, it is safe to assume the fusarium yellows resistance expressed by cabbage and conferred by a single dominant gene should be expressed in the cabbage–collard hybrids. If these hybrids also exhibit some level of resistance to black rot, conferred by the cabbage parents, their value as potential collard cultivars will be enhanced further, because they could be grown under disease-conducive conditions under which all preexisting cultivars would become diseased and suffer productivity losses.

Literature Cited

- Betts, E.M. 1999. Thomas Jefferson's garden book, 1766–1824. Thomas Jefferson Memorial Foundation, Charlottesville, Va.
- Dickson, M.H. and D.H. Wallace. 1986. Cabbage breeding. In: M.J. Bassett (ed.). Breeding vegetable crops. AVI Publ. Co. Westport, Conn.
- Dixon, G.R. 1981. Vegetable crop diseases. MacMillan Publ. LTD, London.
- Farnham, M.W. 1996. Genetic variation among and within United States collard cultivars and landraces as determined by randomly amplified polymorphic DNA markers. *J. Amer. Soc. Hort. Sci.* 121:374–379.
- Farnham, M.W. and J.T. Garrett. 1996. Importance of collard and kale genotype for winter production in the southeastern United States. *HortScience* 31:1210–1214.
- Farnham, M.W., A.P. Keinath, and J.P. Smith. 2001. Characterization of fusarium yellows resistance in collard. *Plant Dis.* 85:890–894.
- Hazzard, T. F. 1831. On vegetable gardens, and the great advantages of a much more general use of vegetable diet. *S. Agr.* 4(12):627–631.
- Johnson, J.R., R.P. Griffin, and C.E. Drye. 1987. Commercial collard production. *Hort. Lft.* 5. Clemson Univ. Coop. Ext. Serv., Clemson Univ., Clemson, S.C.
- Song, K.M., T.C. Osborn, and P.H. Williams. 1988. Brassica taxonomy based on nuclear restriction fragment length polymorphisms (RFLPs). II. Preliminary analysis of subspecies within *B. rapa* and *B. oleracea*. *Theor. Appl. Genet.* 76:593–600.