Cabbage variety evaluation for black rot resistance
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Field experimental design and crop management

Location: Tifton, GA

Entries: 8

Table 1. List of varieties.

Treatment	Variety
1	Monterrey
2	Cheers
3	Acclaim
4	Celebrate
5	1488
6	Capture
7	Melissa
8	TCA-549

Weather conditions

The weather station number 39 from the University of Georgia Weather Network System (http://www.georgiaweather.net/) provided air temperature, relative humidity, solar radiation, wind speed data, and reference evapotranspiration (ETo) every 15 minutes.

Planting date and spacing:

Seeds were planted into 200-cell trays filled with soilless media on 01/10/2019 and greenhouse grown up to transplanting on 02/21/2019. Transplants were planted on 6-in raised beds spaced at 6-ft center. Double rows 18-in spaced were used with 8-in in-row spacing for a plant population of 21,780 plants per acre.

Plot size:

Plots were comprised by 40 plants with 4 replication per variety. A total of 24 plots arranged as a randomized complete block design.

Pest management:

A 3 days pre-planting application of Gold 2XL (2 pints/ac) was performed in the beginning of cabbage season for weed pressure control. After transplant establishment, weekly applications of Exirel (13.5-20.5 fl oz/ac) rotated with Savanto (10.5 fl oz/ac) was conducted to avoid insect pressure. Due to trial objective of evaluate cabbage varieties resistance to black rot, there was no pest management for diseases pressure.

Fertilizer management:

Cabbage was fertilized with 500 lb/acre of 10-10-10 (NPK) at planting and at 21 days after planting. In addition, two more fertilizer applications with 387 lb/acre of 15.5-0-0 (NPK) at 42 and 56 days after planting were performed. A total of 230, 100 and 100 lbs per acre of N, P and K was applied throughout the crop development, respectively.

Irrigation management:

Irrigation water was overhead applied. After transplant, water was daily applied at an irrigation depth of 0.2-in for a 20 days period to ensure plant establishment. After this point, water was applied every 2 days according to the crop evapotranspiration. In the case of rainfall events, irrigation was seceded and returned after 3 days.

Harvest

Cabbage heads were harvested on 91 and 98 days after transplanting (DAT) on 05/23/2019 and 05/20/2019, respectively.

Data collection

The 8 varieties evaluate in this trial (Table 1) were spray-inoculated with a conidial suspension (10^6 conidial/ml) of *Xanthomonas campestris pv. Campestris*. The isolate is a common bacterium causing the black rot disease in Georgia vegetable production, and it was obtained from a cabbage field containing black rot disease pressure in southwest Georgia (2017). Plants inoculation occurred 49 DAT, and weekly screening evaluations for black rot disease pressure were performed up to cabbage harvest (98 DAT). Screening evaluations followed the score criteria for black rot in cabbage leaves as presented in Fig. 1, and an overall score was assigned for each research plot.

Fig. 1. Disease reaction scoring criteria for black rot in cabbage leaves. Scales: 0 = no visible symptoms; 10 = small necrosis or chlorosis near the inoculation point; 30 = typical small V-shaped lesion with black veins; 50 = typical lesion half way to the middle vein; 70 =

typical lesion succeeding to the middle vein; and 90 = lesion reaching the middle vein (Vicente et al. 2002)

Cabbage total yield and internal characteristics were evaluated at the harvest time (91 and 98 DAT). All heads were harvested by cutting the stem at the soil surface and weighed to determination of total yield. A total of 5 cabbage head per plot were randomly selected for internal quality evaluation, and measurements of cabbage head equatorial and polar diameter, core length, and core base width were recorded.

Statistical analysis

Statistical analyses were performed using the software R studio v.3.5.1 (RStudio team, 2018). Total yield and cabbage head internal quality parameters were analyzed with variety as fixed effect. Black rot disease pressure was analyzed with variety, week of screening, and their interaction as fixed effects. When the *F*-value of an ANOVA was significant, a multiple means comparison was performed using Tukey-Kramer at a *p*-value of 0.05.

Results

Spring cabbage was planted in January, transplanted in February, and harvested in May. Air temperatures were lower early season but increased later (Fig. 2). Average daily air temperature was 67 °F. Rainfall accumulation in the spring cabbage season of 2019 was 8.4 inches, which can be considered lower than the 11.8 inches of crop evapotranspiration recorded for the same period of time. Rainfall events were well distributed throughout the season, which reduced the incidence of black rot symptoms that require warm and wet environmental conditions.

Symptoms of BR on cabbage plants started 13 DAI, still, the severity of cabbage BR disease was low in all cultivars and significant differences were not measured at this time. Significant differences for BR severity among cultivars were only measured at 27 DAI, when cultivar Melissa had the highest cabbage BR severity with 19.3%, all other cultivar averaged 2.5% (Fig. 2). The severity of cabbage BR disease increased with crop development, cultivar Melissa had the highest severity during all sampling timing after 27 DAI. The cultivar TCA-549 and Capture had the highest field tolerance to *Xcc* at harvest, but no significant differences were measured from these cultivars to ‘Monterey’, ‘Celebrate’, ‘Capture’, and ‘1488’. At harvest, significant differences among cultivars were Melissa < Acclaim ≤ Cheers ≤ Monterrey ≤ Celebrate ≤ 1488 ≤ Capture ≤ TCA-549.

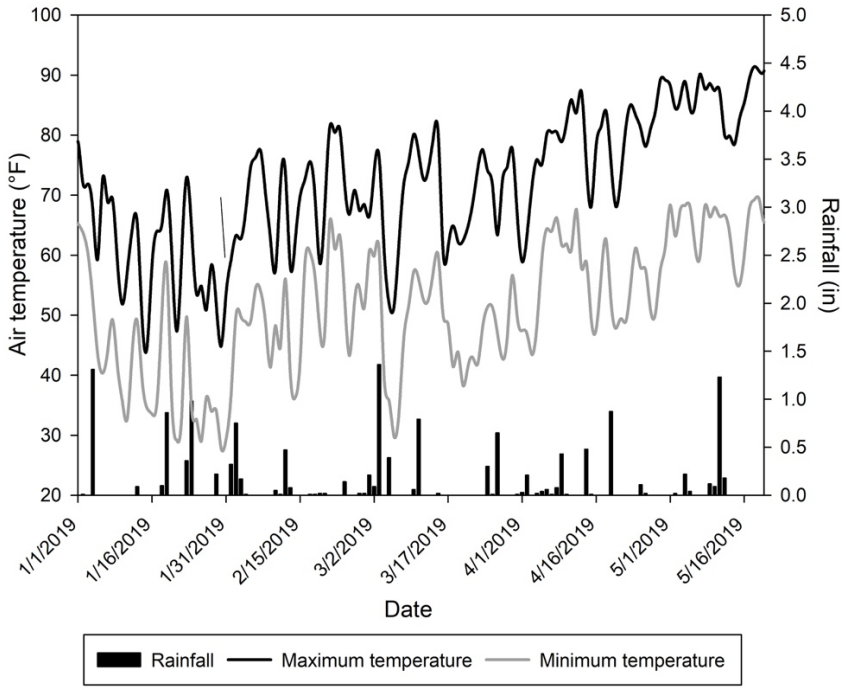

Figure 2. Weather conditions of spring cabbage season of 2019 (January to May) including maximum and minimum air temperature (°F) and rainfall (in) recorded at 15-min intervals. Data retrieved from Georgia Weather Network Systems at the Tifton, GA.

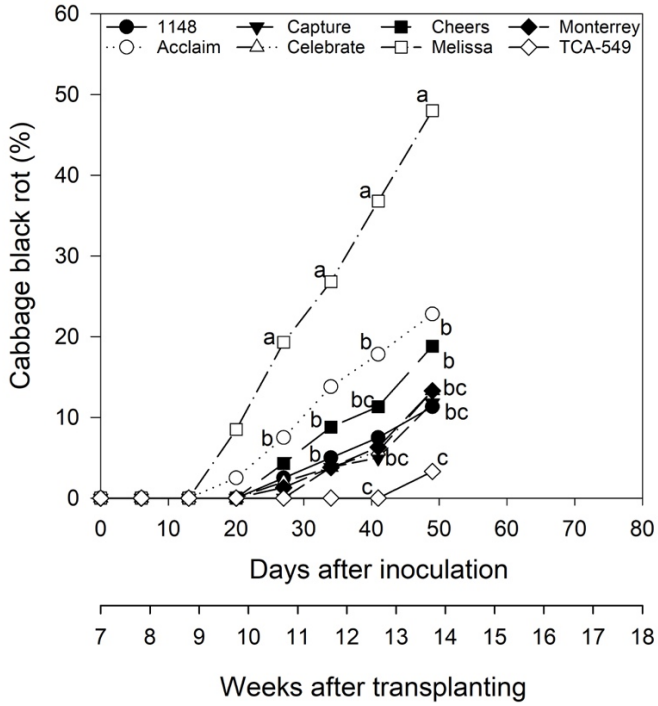

Figure 3. Incidence of black rot among cabbage varieties throughout the crop development in the cabbage spring of 2019 at Tifton, GA. Values followed by different letters within each day after inoculation or week after transplanting indicate significant difference ($p < 0.05$) among varieties.

Total yield was the highest for Acclaim with 53,872 lb./acre, however, there was not difference in total yield among Acclaim and 1148, Cheers, Monterrey, Celebrate, and TCA-549 (table 2). The lowest total yielding varieties were Capture and Melissa, with 37,207 and 35,392 lb./acre, respectively.

Regarding head quality, Melissa was the variety with shortest head with only 4.5 inches of head height. There was no significant difference on head height among any other variety, other than Melissa (table 2). Average head height among top varieties was 5.3 inches. The variety TC-549 was the one with highest value for head width (7.2 inches), and Monterey had the highest core height with 2.6 inches (table 2). There were no significant differences among varieties for core width.

Table 2. Total yield, head height, head width, core height, and core width measured at the harvest time for each variety treatment evaluated in the cabbage spring season of 2019.

Variety	**Total yield**	**Head Height**	**Head Width**	**Core Height**	**Core Width**
	-- lbs./ac --	---------- inches ----------			
Acclaim	53,872 a†	5.6 a	5.9 bc	1.8 c	1.1 a
1488	49,781 a	5.1 a	6.3 b	2.1 bc	1.0 a
Cheers	48,888 a	5.1 a	6.4 b	2.1 bc	1.3 a
Monterrey	49,894 a	5.4 a	6.4 b	2.6 a	1.1 a
Celebrate	46,942 a	5.1 a	6.1 bc	2.0 bc	1.2 a
TCA-549	50,871 a	5.3 a	7.2 a	2.0 bc	1.3 a
Capture	37,207 b	5.2 a	6.2 b	2.2 abc	1.4 a
Melissa	35,392 b	4.5 b	5.5 c	2.3 ab	1.0 a
p-value	<0.001	0.031	<0.001	0.007	0.100

† Values followed by similar letters within a column indicate no significant difference among variety treatments according to Tukey-Kramer mean test.

Figure 4. Visual symptoms of black rot on cabbage crop at the head formation stage of development during the cabbage spring season of 2019.