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 08/15/2018 and greenhouse grown up to transplanting on 10/01/2018. 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 107 days after transplanting (DAT) on 01/16/2019.

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 bacteria 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 35 DAT on 11/05/2018, and weekly screening evaluations for black rot disease pressure were performed up to cabbage harvest (107 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 (107 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

Fall cabbage was planted in October and harvested in January and air temperatures were high early season but dropped later (Fig. 2). Overall, air temperatures varied between 29 and 90 °F, while average daily air temperature was 59 °F. These air temperatures were similar to the average recoded for the same period from 2007-2017 in which average daily air temperature was 58 °F. However, rainfall accumulation in the fall cabbage season of 2018 (20.8 in) was 2-fold higher than the average recorded for the same period (2007-2017), which was 11.1 in. Most of rain events were between 30 and 80 DAP (Fig. 3). and wet conditions on mid-season associated to warm temperatures promote environmental conditions for the incidence of black rot.

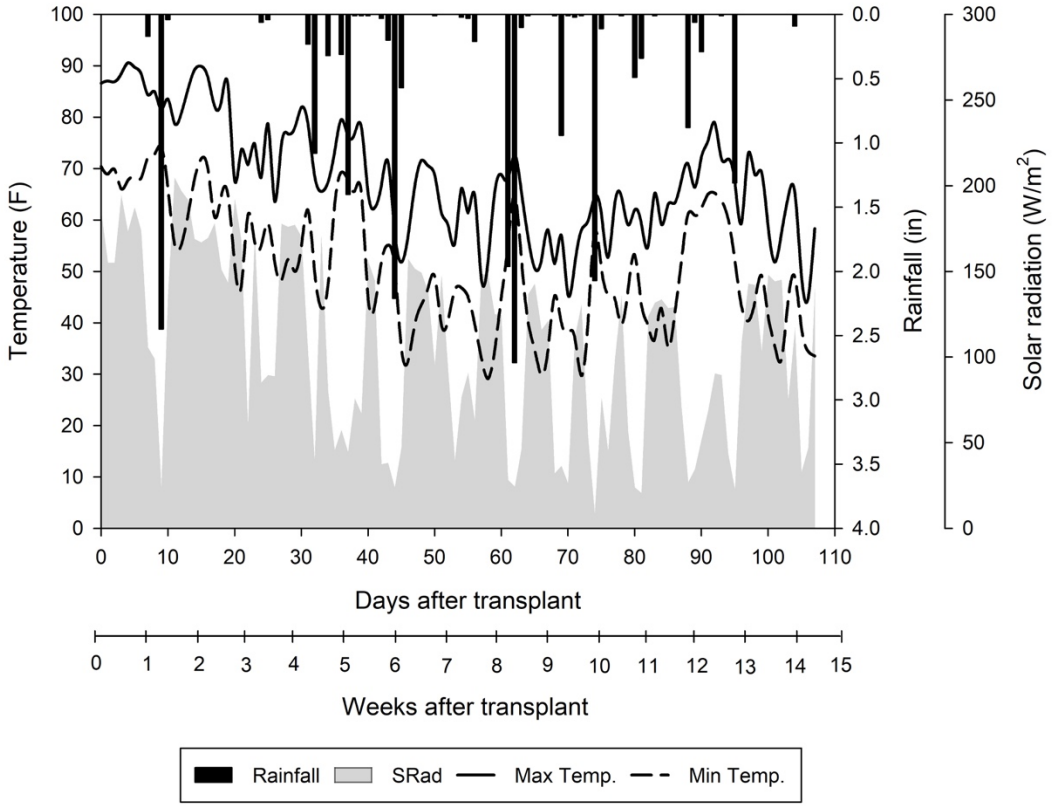

Figure 2. Weather conditions of fall cabbage season of 2018 (October to January) including maximum and minimum air temperature (°F), rainfall (in) and solar radiation (W m^{-2})

recorded at 15-min intervals. Data retrieved from Georgia Weather Network Systems at the Tifton, GA.

The incidence of black rot started 21 days after inoculation (DAI), however, few plots presented the symptoms. Scores were lower than 10, and no significant difference was measured among varieties (Fig. 3). At 28 DAI, black rot was still lower than 10 for all varieties, excepted by Melissa that had the highest score (19). After this point, symptoms of black rot were clear and easy to identify. During the crop development, Melissa had the highest score for black rot, which averaged 85 at harvest. All other varieties had a gradual increase of black rot symptoms as well as Melissa, however, disease pressures were in lower proportions. In particular, the varieties TCA-549 and Capture had the lowest scores starting at 35 DAI, which averaged 18 and 16 at harvest, respectively (Fig. 3). Figure 4 have the visual symptoms of black rot for each variety along the crop development. At harvest, significant differences were Melissa < Cheers ≤ Acclaim ≤ Monterrey < Celebrate ≤ 1488 < TCA-549 ≤ Capture.

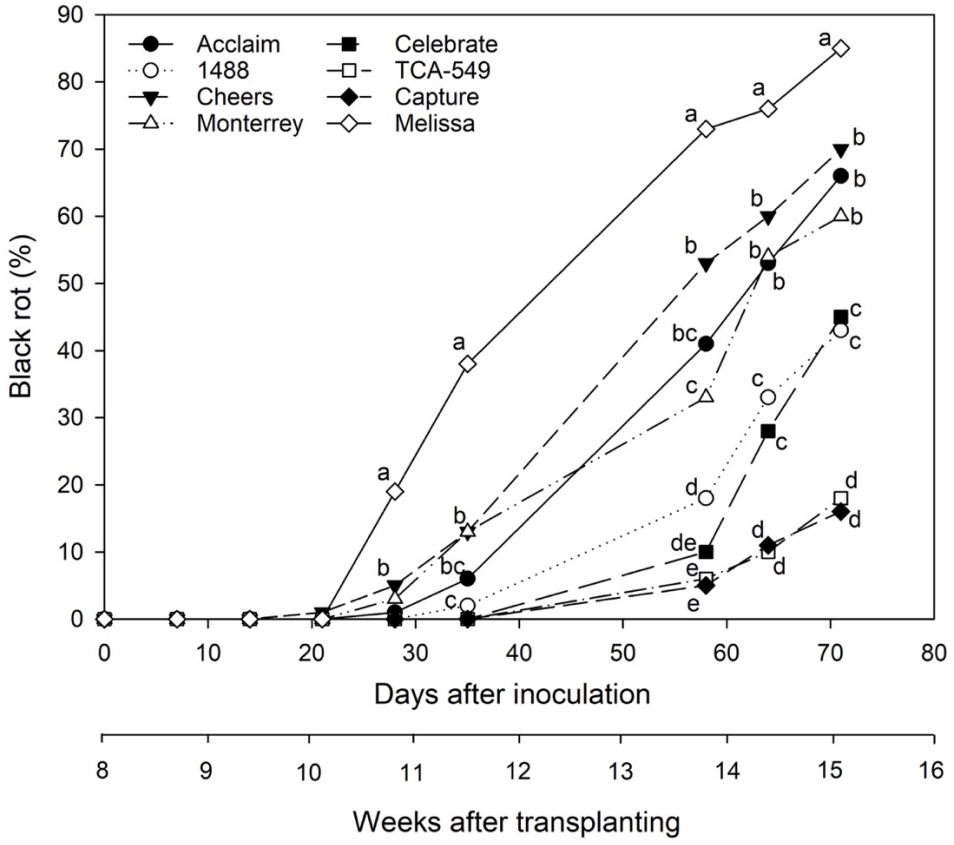

Figure 3. Incidence of black rot among cabbage varieties along the crop development. Values followed by different letters within each day after inoculation or week after transplanting indicate significant difference ($p < 0.05$) among varieties.

Figure 4. Visual symptoms of black rot at harvest time for all varieties evaluated in the cabbage fall season of 2018 in Tifton, GA.

Total yield varied from 25,733 lbs./ac to 47,636 lbs./ac. Cabbage variety Acclaim had the highest total yield among all varieties evaluated in this trial, while Melissa had the lowest total yield. However, Melissa had no significant difference on total yield compared to Capture.

Regarding cabbage internal quality, head height was lower for Melissa compared to all other varieties, except by Cheers that had no significant difference from any variety evaluated. Varieties with the highest head height averaged 5.2-in. Head width was the highest for TCA-549 compared to all varieties evaluated. The TCA-549 had a head width of 7.2-in. The lowest head width was measured for the variety Melissa (5.5-in), however, Melissa had no significant difference on head width from Celebrate (6.1-in) and Acclaim (5.9-in). Core height was highest for Monterrey (2.6-in), which had no significant difference from Capture (2.2-in) and Melisa (2.2-in). The lowest core height was measured for Acclaim with 1.8-in. Finally, there was no significant difference among the varieties evaluated for core width, which averaged 1.2-in.

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 Fall season of 2018.

Variety	**Total yield**	**Head Height**	**Head Width**	**Core Height**	**Core Width**
	-- lbs./ac --	---------- inches ----------			
Acclaim	47,636 a[†]	5.6 a	5.9 bc	1.8 c	1.1 a
1488	39,385 b	5.1 a	6.3 b	2.1 bc	1.0 a
Cheers	39,131 b	5.1 ab	6.4 b	2.1 bc	1.3 a
Monterrey	38,026 b	5.4 a	6.4 b	2.6 a	1.1 a
Celebrate	35,687 b	5.1 a	6.1 bc	2.0 bc	1.2 a
TCA-549	35,649 b	5.3 a	7.2 a	2.0 bc	1.3 a
Capture	29,241 c	5.2 a	6.2 b	2.2 abc	1.5 a
Melissa	25,733 c	4.5 b	5.5 c	2.3 ab	1.0 a
p-value	<0.001	<0.001	<0.001	<0.001	0.52

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