Eleven blackberry cultivar trial and varietal specific susceptibility to certain pathogens: Report to NABG Research Foundation

Part 1; Blackberry cultivar performance trial

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Summary. Horticultural performance of eleven blackberry cultivars, including two primocane-fruiting cultivars was evaluated over three years after planting. Bloom dates were affected by annual environmental conditions although the bloom period was similar among years. 'Natchez' had the highest yield per plant, followed by 'Navaho', 'Von', and 'Osage', although yield declined over the three years of the study for 'Natchez' and remained fairly consistent for 'Osage'. Primocane-fruiting cultivars had very low yields except in year two (first year in production), with 'Prime-Ark® Traveler' having the lowest yield per plant among all cultivars.

Narrative. A blackberry cultivar trial was planted in 2015 at the Clemson University's Musser Fruit Research Center (MFRC), in Seneca SC. This trial comprised the following eleven cultivars: 'Prime-Ark® Freedom', 'Prime-Ark® Traveler', 'Arapaho', 'Natchez', 'Osage', 'Ouachita', 'Navaho', 'Von', 'Apache', 'Triple Crown' and 'Chester'. Plants were grown in a two-wire system, and there were 15 plants per cultivar, with three replications of five plants per cultivar in a randomized complete block design. In-row plant spacing was three feet.

Bloom and harvest dates, and fruit yield and weight were recorded over three years. 50% bloom ocurred between April 5 and May 10 in 2016 and April 4 and May 11 in 2017 (Table 1). In 2018, spring temperatures fluctuated remarkably with cycles of warm and cold weather that caused a delay of bloom and harvest dates of one week and up to ten days for some cultivars (Table 1). All cultivars went from 50% to 90% bloom in a period of 3-8 days, independently of the year.

Table 1. 50% and 90% bloom dates for 11 blackberry cultivars (2016-2018)

Cultivar	**2016**		**2017**		**2018**	
	50%	**90%**	**50%**	**90%**	**50%**	**90%**
Prime-Ark® Freedom	5-Apr	8-Apr	4-Apr	9-Apr	13-Apr	18-Apr
Prime-Ark® Traveler	14-Apr	19-Apr	11-Apr	17-Apr	16-Apr	24-Apr
Arapaho	18-Apr	20-Apr	15-Apr	20-Apr	27-Apr	2-May
Natchez	14-Apr	19-Apr	13-Apr	16-Apr	25-Apr	1-May
Osage	14-Apr	21-Apr	11-Apr	19-Apr	25-Apr	1-May
Ouachita	20-Apr	25-Apr	20-Apr	25-Apr	30-Apr	4-May
Navaho	26-Apr	29-Apr	24-Apr	28-Apr	4-May	9-May
Von	25-Apr	28-Apr	25-Apr	28-Apr	6-May	11-May
Apache	21-Apr	25-Apr	20-Apr	22-Apr	4-May	8-May
Triple Crown	10-May	12-May	1-May	5-May	16-May	20-May
Chester	10-May	13-May	8-May	11-May	22-May	30-May

The first crop was produced in 2016. Harvest season of the floricane fruit started on May 13, with 'Prime-Ark® Freedom' being the first cultivar producing fruit, and finished on August 11 with 'Apache' and 'Chester' being the last ones in being harvested (Table 2). Overall, the harvest season lasted between four

and six weeks for most cultivars, with a shorter season for the cultivars producing fruit in May and a longer season for those harvested in June and July. The length of the harvesting season increased in 2017 and 2018 (second and third year, respectively), with most cultivars producing blackberries over six to eight weeks (Table 2). Primocane fruit was also harvested from 'Prime-Ark® Freedom' and 'Prime-Ark® Traveler' between July and August in 2016, and between May and Jun (Table 3).

Table 2. First and last date of harvest of floricane fruit from 11 blackberry cultivars (2016-2018)

Cultivar	**2016**		**2017**		**2018**	
	First	**Last**	**First**	**Last**	**First**	**Last**
Prime-Ark® Freedom	13-May	13-Jun	19-May	26-Jun	25-May	22-Jun
Prime-Ark® Traveler	19-May	16-Jun	22-May	5-Jul	25-May	18-Jul
Arapaho	25-May	21-Jun	22-May	5-Jul	25-May	11-Jul
Natchez	27-May	28-Jun	22-May	13-Jul	25-May	18-Jul
Osage	31-May	6-Jul	25-May	25-Jul	29-May	24-Jul
Ouachita	6-Jun	13-Jul	29-May	25-Jul	4-Jun	25-Jul
Navaho	9-Jun	13-Jul	5-Jun	9-Aug	8-Jun	14-Aug
Von	13-Jun	3-Aug	19-Jun	15-Aug	12-Jun	14-Aug
Apache	16-Jun	11-Aug	8-Jun	9-Aug	15-Jun	1-Aug
Triple Crown	24-Jun	3-Aug	22-Jun	9-Aug	19-Jun	8-Aug
Chester	1-Jul	11-Aug	5-Jul	22-Aug	3-Jul	29-Aug

Table 3. First and last date of harvest of primocane fruit from Prime-Ark® cultivars (2016-2018)

Cultivar	**2016**		**2017**		**2018**	
	First	**Last**	**First**	**Last**	**First**	**Last**
Prime-Ark® Freedom	7-Jul	11-Aug	5-Jul	9-Aug	11-Jul	8-Aug
Prime-Ark® Traveler	13-Jul	11-Aug	18-Jul	22-Aug	18-Jul	29-Aug

Cultivars such as 'Prime-Ark® Freedom', 'Prime-Ark® Traveler', 'Arapaho', 'Natchez', and 'Apache' had their highest yield in 2016 (Table 4). Afterwards, yield steadily declined through the years. 'Osage' also had its highest yield in 2016 although was fairly consistent from year to year, and yield was still the highest among all varieties in 2018. 'Prime-Ark® Freedom' had some freeze damage in 2017 and was not very productive in 2018 either. 'Prime-Ark® Traveler' was planted three weeks later than the other cultivars and this contributed to its low yield in 2016. Severe tip dieback in years 2017 and 2018 reduced yield in these two years (see second part of the narrative on blackberry primocane tip dieback). 'Natchez' had the highest accumulated yield among all cultivars over the three years of the study, followed by 'Navaho' and 'Von'. Table 5 shows estimated fruit yield per acre based on the yield per plant.

'Prime-Ark® Freedom' had the greater fruit weight among all cultivars (Table 6). Independently of yield, fruit weight was very consistent for 'Prime-Ark® Freedom' over the three years of study. This was not the case for other cultivars such as 'Osage', 'Ouachita', 'Von' and 'Triple Crown', as these cultivars showed a declining fruit weight throughout the study, even for cultivars that had similar yield between different years.

Table 4. Fruit yield (lb/plant) of 11 blackberry cultivars for the first three years of production

Cultivar	**2016**	**2017**	**2018**	**Accumulated yield**
Prime-Ark® Freedom	22.1+0.8[z]	2.5+4.6	6.6+0.6	37.2
Prime-Ark® Traveler	10.8+0.9	7.2+3.7	4.9+1.4	28.9
Arapaho	20.4	7.9	7.2	35.5
Natchez	26.6	15.2	11.5	53.3
Osage	16.1	12.6	13.4	42.1
Ouachita	14.2	14.3	7.6	36.1
Navaho	15.9	20.9	11.0	47.8
Von	15.6	20.6	10.6	46.8
Apache	17.2	8.9	4.0	30.1
Triple Crown	13.0	18.6	6.1	37.7
Chester	5.9	26.3	9.1	41.3

[z]Values for Prime-Ark® Freedom and Prime-Ark® Traveler include yield from floricane (first value) and primocane (second value) fruit

Table 5. Estimated yield (lb/acre) of 11 blackberry cultivars for the first three years of production

Cultivar	**2016**	**2017**	**2018**	**Accumulated yield**
Prime-Ark® Freedom	15,344	4,745	4,451	24,540
Prime-Ark® Traveler	7,783	7,297	3,287	18,367
Arapaho	13,649	5,246	4,835	23,748
Natchez	17,806	10,156	7,709	35,671
Osage	10,804	8,461	8,977	28,242
Ouachita	9,537	9,611	5,071	24,219
Navaho	10,672	14,018	7,385	32,075
Von	10,421	13,793	7,090	31,304
Apache	11,541	5,994	2,712	20,247
Triple Crown	8,711	12,480	4,098	25,289
Chester	3,921	17,615	6,117	27,653

Table 6. Average fruit weight of 11 blackberry cultivars (2016-2018)

Cultivar	**2016**	**2017**	**2018**
Prime-Ark® Freedom	9.7/11.6	9.7/10.6	9.8/7.8
Prime-Ark® Traveler	7.1/5.3	5.9/5.2	6.2/4.2
Arapaho	5.8	5.3	5.3
Natchez	8.4	6.9	7.1
Osage	6.0	5.7	5.3
Ouachita	6.8	6.2	5.9
Navaho	5.5	5.3	5.0
Von	6.2	5.5	5.↓
Apache	7.7	8.0	7.4
Triple Crown	7.8	6.7	6.6
Chester	4.8	5.3	4.7

Part 2; Blackberry primocane tip dieback: Potential causes and cultivars affected

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Summary. Severe tip dieback was observed in 2016 in a cultivar trial block on 'Prime-Ark® Traveler' blackberry cultivar at the Musser Fruit Research Center (MFRC), Seneca, SC and in other locations, including one more location in SC and one in VA. Secondary pathogens such as Alternaria and Fusarium were consistently isolated from affected tissue and controlled experiments did establish a cultivar-specific sensitivity of canes to these pathogens. Mites and thrips were observed that year in all locations sampled and an increase in insecticide applications and establishment of mite control at MFRC resulted in no tip dieback symptoms the following year. We hypothesize that the secondary pathogens were enabled to do damage in 2016 as a consequence of insect and/or mite damage. This research establishes the importance of insect and mite management to control tip dieback of some blackberry cultivars.

Narrative. Tip dieback was first observed in years prior on the blackberry cultivar 'Arapaho' (http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=8030), and was believed to be of physiological cause based on an interaction between the cultivar and cooler climates. Recently, similar primocane tip dieback was observed on blackberry cultivars grown at the Musser Fruit Research Center (MFRC) in Seneca, South Carolina. Heavily affected cultivars include 'Prime-Ark® Traveler', 'Arapaho', and 'Osage'. Fruit workers in Virginia, Arkansas, and Pennsylvania also reported the same issue on Prime-Ark® cultivars. The symptoms usually contain 2 to 4 inches of wilt, followed by a blackening of the tip. The issue seems to be only restricted to the top 4 or 5 inches (Fig. 1).

The incidence of tip dieback at the MFRC varied between cultivars (Table 1). Most frequently affected was 'Prime-Ark® Traveler' (Table 1), but other cultivars including 'Apache', 'Arapaho', 'Osage', 'Ouachita', and 'Prime-Ark® Freedom' were also affected. However, 'Chester' and 'Navaho' seemed unaffected. During 2016 very few insecticide applications were made and no miticides were applied. No tip dieback was observed in the same trial in 2017.

Fig. 1. Primocane tip dieback.

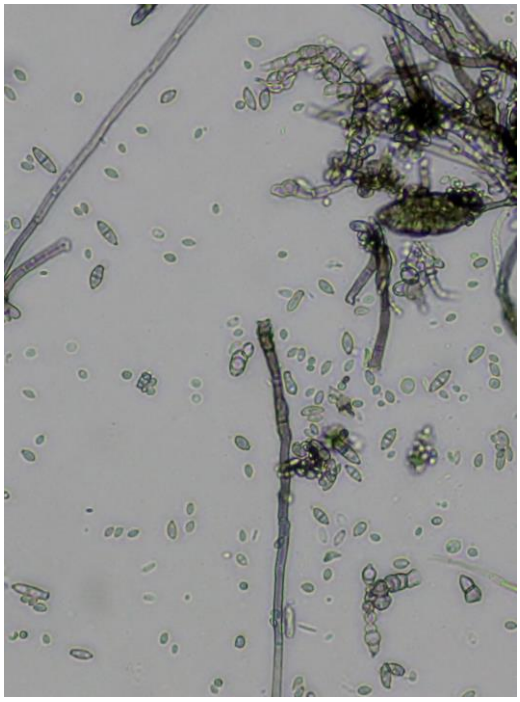

Fig. 2. Fungal spores obtained from dieback samples (Photo by Lauren Darnell).

Certain fungi may have been involved in the occurrence of the observed dieback. We found signs of pathogens in form of spores on the symptomatic cane tips from the MFRC and from tissue obtained from an experimental block at Virginia Tech. Spores observed varied in size and shape (Fig. 2), indicating that several different fungi were involved. We conducted fungal isolations and sequenced the ribosomal Intergenic Spacer Regions 1 and 2 to identify the pathogens to the genus level (Table 2). Results indicated consistent presence of *Alternaria* and *Fusarium* species as well as occasional isolations of *Botryosphaeria, Pestalotiopsis,* and *Phomopsis* (Table 2).

Cultivar susceptibility to the pathogens consistently isolated in 2016 was investigated by inoculating detached primocane tips. Similar to our field observation, Prime-Ark® Traveler was one of most susceptible cultivars in this assay. 'Navaho', 'Osage', and 'Von' were also highly susceptible to *Alternaria* (Table 3). The experiment was repeated in 2017, however, no symptoms were recorded on any of the cultivars inoculated with the same *Alternaria* isolate. Inoculations with *Fusarium* conducted in 2017 also did not yield symptoms (data not shown).

Table 1 Incidence of tip dieback on different blackberry cultivars[a].

	Tip dieback incidence			
Cultivars	**Rep 1**	**Rep 2**	**Rep 3**	**Mean**
Apache	25	35	15	25 ± 8.2
Arapaho	25	50	15	30 ± 14.7
Chester	0	0	0	0
Natchez	0	0	0	0
Navaho	10	10	15	11.7 ± 2.4
Osage	20	25	50	31.7 ± 13.1
Ouachita	10	40	30	26.7 ± 12.5
Prime-Ark® Traveler	65	70	80	71.7 ± 6.2
Prime-Ark® Freedom	40	15	15	23.3 ± 11.8
Triple Crown	5	5	0	3.3 ± 2.4
Von	55	5	0	20 ± 24.8

[a] Data based on 20 primocanes of each of 3 replicates of each cultivar.

Table 2 Plant pathogens isolated from symptomatic tips[a]

Fungi	**VA**	**SC location 1**	**SC location 2**
Alternaria	x	x	x
Botryosphaeria	x	x	-
Fusarium	x	x	x
Pestalotiopsis	x	x	-
Phomopsis	x	-	-

[a] fungi were identified by ITS sequencing; 'x' indicates the presence of the pathogen.

It is still unclear what caused the tip dieback in 2016 at the MFRC, Virginia, and other locations. Entomologists at University of Arkansas have found that broad mites were associated with terminal and lateral damages on 'Prime-Ark®' cultivars. Such damage may have provided a gateway into the plant tissue for the otherwise weak cane pathogens Alternaria and Fusarium. According to the MFRC spray records, no miticides were used on the blackberries with dieback symptoms in 2016 and broad mites were observed. In contrast, the insecticide Delegate was applied in 14 day intervals in 2017 together with a single miticide application (Acramite) when mites flared up. The management of thrips (Delegate) and mites (Acramite) may therefore be responsible for the lack of tip dieback in 2017.

Table 3 Symptom expression (%) and lesion length (cm) of detached primocanes collected in 2016 and 2017 after inoculation with an *Alternaria* isolate collected in 2016

Cultivar	2016		2017	
	Symptom expression	**Lesion length**	**Symptom expression**	**Lesion length**
Apache	40	3.8	0	0
Arapaho	50	3.3	0	0
Chester	12.5	0.6	0	0
Natchez	0	0	0	0
Navaho	100	4.5	0	0
Osage	80	4.6	0	0
Ouachita	8.3	1.0	0	0
Prime-Ark® Freedom	50	4.6	0	0
Prime-Ark® Traveler	90	5.1	0	0
Triple Crown	20	1.25	0	0
Von	80	4.8	0	0