

**CROP:** Garlic (*Allium sativum* L.)

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**TITLE: EVALUATION OF GARLIC CULTIVARS FROM THE CLEAN SEED PROGRAM IN THE 2023-2025 FIELD SEASONS**

**METHODS:** Garlic cloves of seven cultivars were hand planted near Grand Bend, Ontario, in Brookston clay loam 4 October 2023 and 8 October 2024 and near Dashwood, Ontario, in Huron clay loam 24 October 2023 and 17 September 2024. An additional field site in Perth silt loam was chosen near Arthur, Ontario, to use as a third location and planted 22 October 2024. Each cultivar had two or more lines planted at each site, one that has been grown by conventional growing methods while the other was second and third generation planting stock that had been originally produced by the Ontario Crops Research Centre – New Liskeard formally known as the New Liskeard Agricultural Research Station (NLARS) SPUD Unit, Clean Seed Program (CSP) (**Figure 1**). The CSP cultivars were submitted to the SPUD Unit germplasm by meristem tip culture between 2008–2020, were virus-indexed for commercially recognized viruses, and micro-propagated to yield roundels that were planted near Bright’s Grove, Ontario, in Brookston clay loam 9 October 2022 and harvested the following year 27 July 2023. The conventional lines were propagated by splitting bulbs into cloves each year and grown near Dashwood, Ontario, in Huron clay loam from 2018 to present. Cultivars from the CSP include Duganski MPS (Marbled Purple Stripe), Duganski White, Guelph, Music, Polish White, Portugal 1 Azoles, Red Russian MPS (Marbled Purple Stripe), and Ukraine. The genetics of Guelph, Polish White, Portugal 1 Azoles, Red Russian MPS, and Ukraine are direct comparisons of identical genetics at all field sites as the CSP lines that were started from scapes of the conventional counterparts (**Figure 2**). The CSP lines of Music were originally started from scapes from genetics not in this trial and conventional genetics of Duganski MPS and Duganski White were not retained from cultivar trials conducted between 2018–2022 and therefore direct comparisons may not be accurate as it is not certain that the genetics are identical. The average clove weight for each replicant cultivar line where a comparison is made in 2025 were as equal as possible at planting +/- 3 grams per 10 cloves. (**Table 1**). At all locations, the trial was arranged in a randomized complete block design with four replicates. In Dashwood and Grand Bend, plants from the CSP separated from conventional plants to avoid contamination of soil pathogens. In Arthur, CSP and conventional plants were grown side by side. In Grand Bend, each replicate consisted of three rows of plants planted 10 cm (4 in.) apart in groups of 10 plants at a density of ~170k plants per acre. In Dashwood, each replicate consisted of a single row (2 m long) with 10 plants per row to give a density of ~65k plants per acre. An exclusion net (ProtekNet 25g knitted, 0.35 mm x 0.35 mm) was added over the Grand Bend plants 15 April 2024 / 29 April 2025 and was removed at harvest. In Arthur, each replicate consisted of a single row (1.5 m long) to give a density of ~150k plants per acre. Black plastic was used as weed control at the Grand Bend location while plants were hand weeded as necessary at Dashwood and Arthur each year. At the Dashwood location, supplemental drip irrigation was added 21 May 2024 with irrigation applied as necessary up until two weeks before harvest. In 2025, no irrigation was utilized at the Dashwood location. For the first growing season at the Grand Bend location, plants were hand-watered at planting in 2023, and again in May 2024. For the second season at the Grand Bend location, plants were supplemented with drip irrigation from May until the end of June 2025. Plants were hand-watered at the Arthur location 4 June 2024. Visual tip dieback assessments were recorded 4 June 2025 at the Arthur location due to stark differences observed between the conventional and CSP lines. Tip dieback was estimated by the percentage of yellowing on every leaf of the plant. Scaping was conducted in Dashwood and Grand Bend 11 June in 2024/2025 and in Arthur 12 June 2025. Plants were harvested when an average of 50 % of the garlic leaves had senesced 22 July 2024 in both locations and 21 July 2025 in Dashwood and Grand Bend. The Arthur location was harvested 23 July 2025. After harvest, bulbs were cleaned, placed in mesh bags, and cured in a pallet box within a forced air-drying shed for approximately 10 days with garlic dry weights collected on 6 August 2024 and 8 August 2025. Data were analyzed using

SAS version 9.3 (SAS Institute, Cary NC). Means were separated using Tukey-Kramer multiple mean comparison test ( $P = 0.05$ ).

**RESULTS:** As outlined in **Tables 1–2** and **Figures 3–5**. Direct comparisons were only made in the 2024–2025 field season as it took two field seasons for the roundels to produce clean seed cloves that were the same average starting weight as the conventional cloves (**Table 1**, column ‘**Conventional to Clean % Increase**’, and **Figures 3–4**).

**CONCLUSIONS:** The lines from the CSP where direct comparisons can be made attributed to an average yield increase of 30% in Grand Bend, 25% in Dashwood and 65% in Arthur.

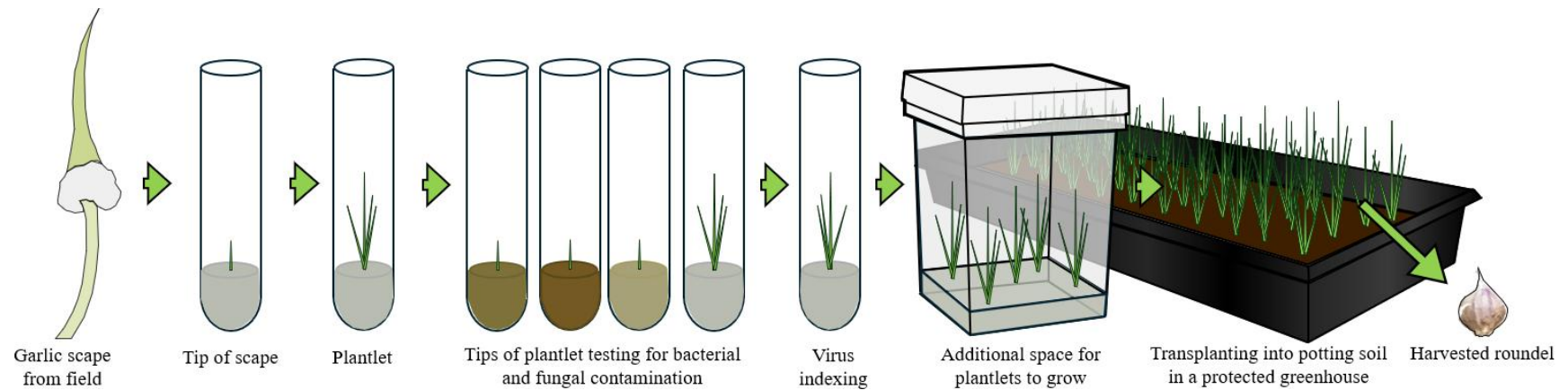
In **Grand Bend**, the Guelph line had the highest increase (40%) in yield compared to the conventional line while Red Russian MPS had the lowest increase (18%).

In **Dashwood**, the conventional Portugal 1 Azoles and Red Russian MPS were mistakenly not planted in 2024. Therefore, no comparisons could be made between the clean and conventional lines of these cultivars at this location. Polish White had the greatest increase in yield (37%) compared to the conventional line while Ukraine had the lowest increase (13%). Throughout the growing season, tip dieback was noticeably more pronounced 3 June 2025 in the conventional lines relative to the CSP lines, but no analytical data was recorded.

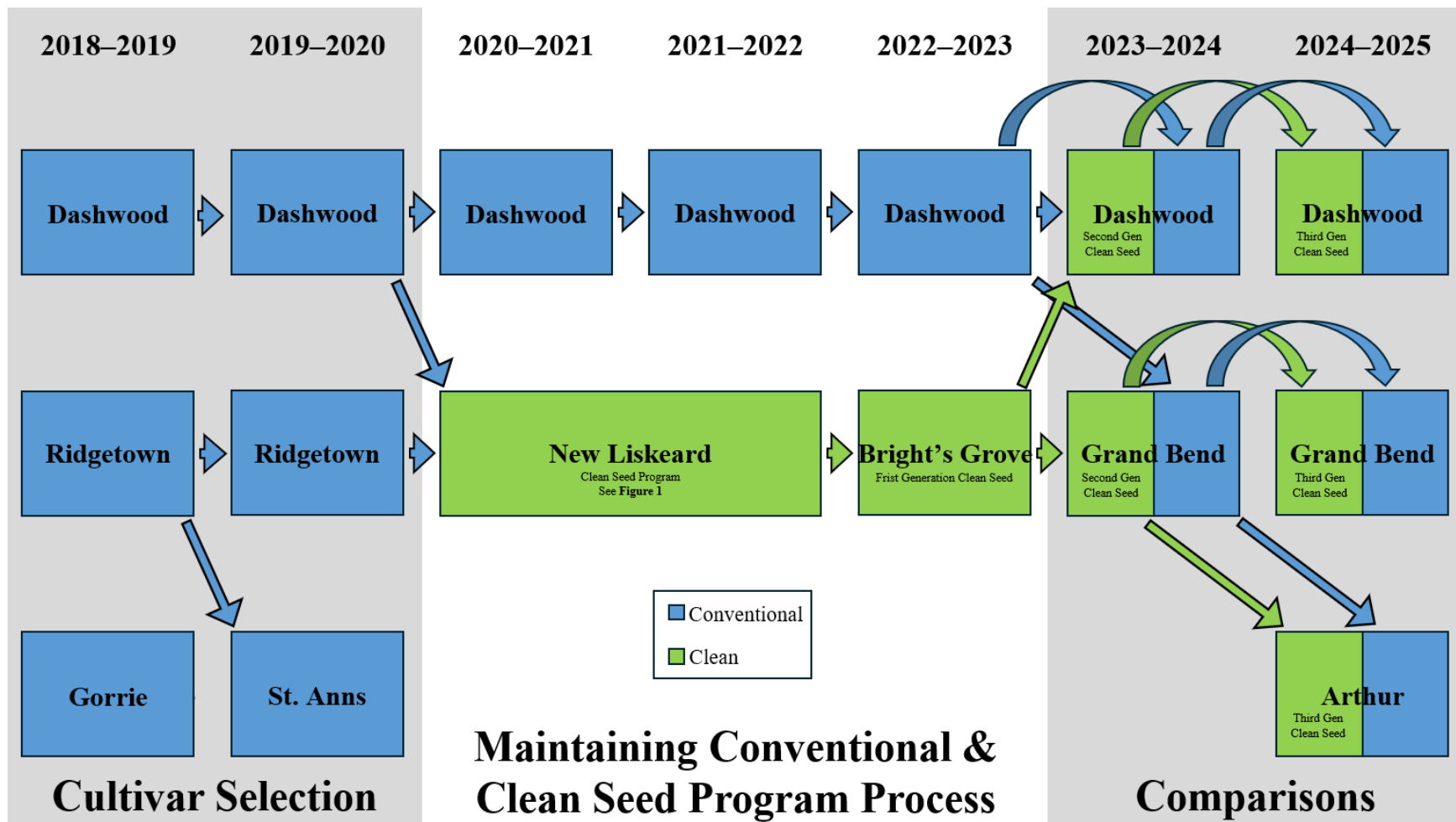
At the **Arthur** location, plants were not grown in the same soil type the year prior to the comparison (2023–2024). All cloves planted in Arthur in 2024 were cracked from bulbs grown in Grand Bend from 2023–2024. This is of particular interest since from previous cultivar trials it has been noted that some cultivars adapt more readily to new soil types or production practices than others. Guelph had the highest increase in yield (101%) compared to the conventional line and Ukraine had the lowest increase (19%). Tip dieback assessments 4 June 2025 showed an average tip dieback of 15.4 % in the conventional lines versus 1.5 % in the CSP lines (**Table 2, Figure 5**). Tip dieback prior to harvest was more pronounced in the conventional lines in Dashwood and Arthur than the CSP lines, however there were no major differences were observed in Grand Bend. With an average increase of 61% in weight at the Arthur site when averaging all five lines, it appears that the lines from the CSP had more of an advantage than their conventional counterparts in Arthur compared to Grand Bend, even though the planting stocks were identical. The Arthur location was planted two weeks later (Arthur was planted 22 October 2024 and Grand Bend was planted 8 October 2024) but all other factors such as storage conditions prior to planting and time between cracking and planting were similar. The CSP lines may have an easier time adapting to new soil types or may be better at getting established before winter than their conventional counterparts. While the precipitation and soil moisture levels were not recorded at either field site, the Arthur location may have experienced dryer conditions than Grand Bend in June/July 2025.

In summary, lines from the CSP outperformed their conventional counterparts in all locations where the original genetics was conserved, and where direct comparisons could be made. The CSP lines of Music and Duganski generally performed better than their conventional counterparts, but it is unknown if these genetics are identical.

**ACKNOWLEDGEMENTS:** Thank you to the staff at the SPUD Unit for providing guidance and assistance throughout the duration of this project. In kind contributions were made by Dean, Martin, and Teresa Van Raay of Van Raay Farms, Nathan and Ian Teetzel of G & L Farms, Bob Romaniuk of Brant County Garlic, Julie Fleischauer of Golden Acres Farm, Alf Semenuk of Pioneer Nursery, and Tony McNamara of Acadian Shamrock Farm. Thank you to Joseph Roy, Dan Stein, Sasha VanDyk, Kristin Speight, Summer Hagen, Kendra Workman, McKenzie Susil, Stephanie Vickers, Leah Ritcey-Thorpe, Caio Correa, Nicole Berardi, Katie Goldenhar, Cora Loucks, Matteo Girardo, Emily Forrester, Katie Weninger, Natalia Karsztun, Matthew Lawford and Dennis Van Dyk for your assistance in planting, weeding or harvesting part of this trial over the past eight years. Thank you for the support from the Garlic Grower Association of Ontario.



**Figure 1.** The CSP lines were created through meristem tip culture. Garlic scapes were submitted to the SPUD Unit germplasm by meristem tip culture between 2008–2020, were tested for contamination, were virus-indexed for commercially recognized viruses, and micro-propagated to create plantlets. Plantlets were transplanted into the greenhouse to yield roundels.



**Figure 2.** Timeline of planting stock sources from 2018–2024. The genetics of Guelph, Polish White, Portugal 1 Azoles, Red Russian MPS, and Ukraine are direct comparisons of identical genetics at all field sites in 2025 as the Clean Seed Program (CSP) lines that were started from scapes of the conventional counterparts. The CSP lines of Music were originally started from scapes from genetics not in this trial and conventional genetics of Duganski MPS and Duganski White were not retained from cultivar trials conducted between 2018–2022 and therefore direct comparisons may not be accurate as it is not certain that the genetics are identical.

**Table 1.** Average clove weights at planting, dry weight after harvest plus cure and bulb weight to clove weight ratios of multiple hardneck garlic cultivars from 2023–2025.<sup>1, 2</sup>

Location	Cultivar	Clove Weight at Planting 2023 (g) <sup>3</sup>	Cured Bulb Weight 2024 (g)	2023-2024 Bulb Weight to Clove Weight Ratio <sup>3</sup>	Clove Weight at Planting 2024 (g) <sup>3</sup>	Cured Bulb Weight 2025 (g)	2024-2025 Bulb Weight to Clove Weight Ratio <sup>3</sup>	Conventional to Clean % Increase <sup>4</sup>
Grand Bend	Guelph – Clean 2021	6.7	44.1 a	6.6	9.7	51.9 a	5.3	40 %
	Guelph – Conventional	8.2	39.0 a	4.8	9.5	37.1 b	3.9	
	Polish White – Clean 2021	5.9	38.0 a	6.5	9.1	57.9 a	6.4	28 %
	Polish White – Conventional	8.4	40.8 a	4.9	9.1	45.2 b	5.0	
	Portugal 1 Azoles – Clean 2021	5.9	43.8 a	7.4	10.3	55.2 a	5.4	38 %
	Portugal 1 Azoles – Conventional	8.4	39.0 a	4.6	9.5	40.1 b	4.2	
	Red Russian MPS <sup>5</sup> – Clean 2021	7.9	43.3 a	5.5	11.4	56.7 a	5.0	18 %
	Red Russian MPS <sup>5</sup> – Conventional	9.5	42.5 a	4.5	8.4	47.9 a	5.7	
	Ukraine – Clean 2021	6.4	41.3 a	6.4	8.2	47.6 a	5.8	31 %
	Ukraine – Conventional	8.1	38.2 a	4.8	8.1	36.2 a	4.5	
	Music – Clean 2008	7.6	44.6 a	5.9	9.2	53.8 a	5.9	
	Music – Clean 2021	7.8	43.5 a	5.6	8.7	51.3 a	5.9	
	Music – Conventional	7.6	45.0 a	6.0	9.0	37.7 b	4.2	
	Duganski White – Clean 2021	6.2	40.8 b	6.6	5.5	37.6 b	6.8	
	Duganski MPS <sup>5</sup> – Clean 2021	5.2	34.2 b	6.6	7.3	46.7 a	6.4	
	Duganski MPS <sup>5</sup> – Conventional	14.5	53.8 a	3.7	7.3	37.8 b	5.2	
Dashwood	Guelph – Clean 2021	4.9	78.9 a	16.3	10.8	80.1 a	7.4	25 %
	Guelph – Conventional	8.2	57.4 b	7.0	10.5	64.2 b	6.1	
	Polish White – Clean 2021	3.3	65.3 a	20.1	9.4	94.1 a	10.1	37 %
	Polish White – Conventional	9.2	72.9 a	8.0	9.4	68.6 a	7.3	
	Portugal 1 Azoles – Clean 2021	3.5	68.5 a	19.6	11.6	85.9	7.4	
	Portugal 1 Azoles – Conventional	8.0	64.0 a	8.0				
	Red Russian MPS <sup>5</sup> – Clean 2021	4.4	82.7 a	18.8	12.6	81.4	6.5	
	Red Russian MPS <sup>5</sup> – Conventional	12.4	92.2 a	7.5				
	Ukraine – Clean 2021	3.1	65.8 a	21.2	13.1	89.3 a	6.8	13 %
	Ukraine – Conventional	8.7	66.7 a	7.7	12.3	79.4 a	6.5	
	Music – Clean 2008	4.6	85.3 a	18.7	11.3	71.6 a	6.3	
	Music – Clean 2021	4.1	72.9 b	17.8	11.6	77.0 a	6.6	
	Music – Conventional	11.7	75.7 ab	6.5	11.4	83.2 a	7.3	
	Duganski White – Clean 2021	3.9	89.8 a	23.0	8.9	67.7 b	7.6	
	Duganski MPS – Clean 2021	4.4	63.3 b	14.6	18.6	95.8 a	5.2	

Location	Cultivar	Clove Weight at Planting 2023 (g) <sup>3</sup>	Cured Bulb Weight 2024 (g)	2023-2024 Bulb Weight to Clove Weight Ratio <sup>3</sup>	Clove Weight at Planting 2024 (g) <sup>3</sup>	Cured Bulb Weight 2025 (g)	2024-2025 Bulb Weight to Clove Weight Ratio <sup>3</sup>	Conventional to Clean % Increase
Arthur <sup>6</sup>	Guelph – Clean 2021				8.4	65.5 a	7.8	101 %
	Guelph – Conventional				7.6	32.6 b	4.3	
	Polish White – Clean 2021				7.2	55.9 a	7.8	62 %
	Polish White – Conventional				6.7	34.5 b	5.2	
	Portugal 1 Azoles – Clean 2021				8.3	68.1 a	8.2	73 %
	Portugal 1 Azoles – Conventional				7.0	39.3 b	5.6	
	Red Russian MPS <sup>5</sup> – Clean 2021				9.3	60.8 a	6.6	62 %
	Red Russian MPS <sup>5</sup> – Conventional				7.0	37.6 b	5.4	
	Ukraine – Clean 2021				7.8	52.9 a	6.8	29 %
	Ukraine – Conventional				6.9	41.0 b	5.9	
	Music – Clean 2008				8.4	57.4 a	6.9	
	Music – Clean 2021				7.0	49.7 a	7.2	
	Music – Conventional				7.3	36.0 b	4.9	
	Duganski White – Clean 2021				5.7	56.5 a	10.0	
	Duganski MPS – Clean 2021				5.5	41.1 b	7.5	
	Duganski MPS – Conventional				8.0	37.4 b	4.7	

<sup>1</sup> All treatments had four replications.

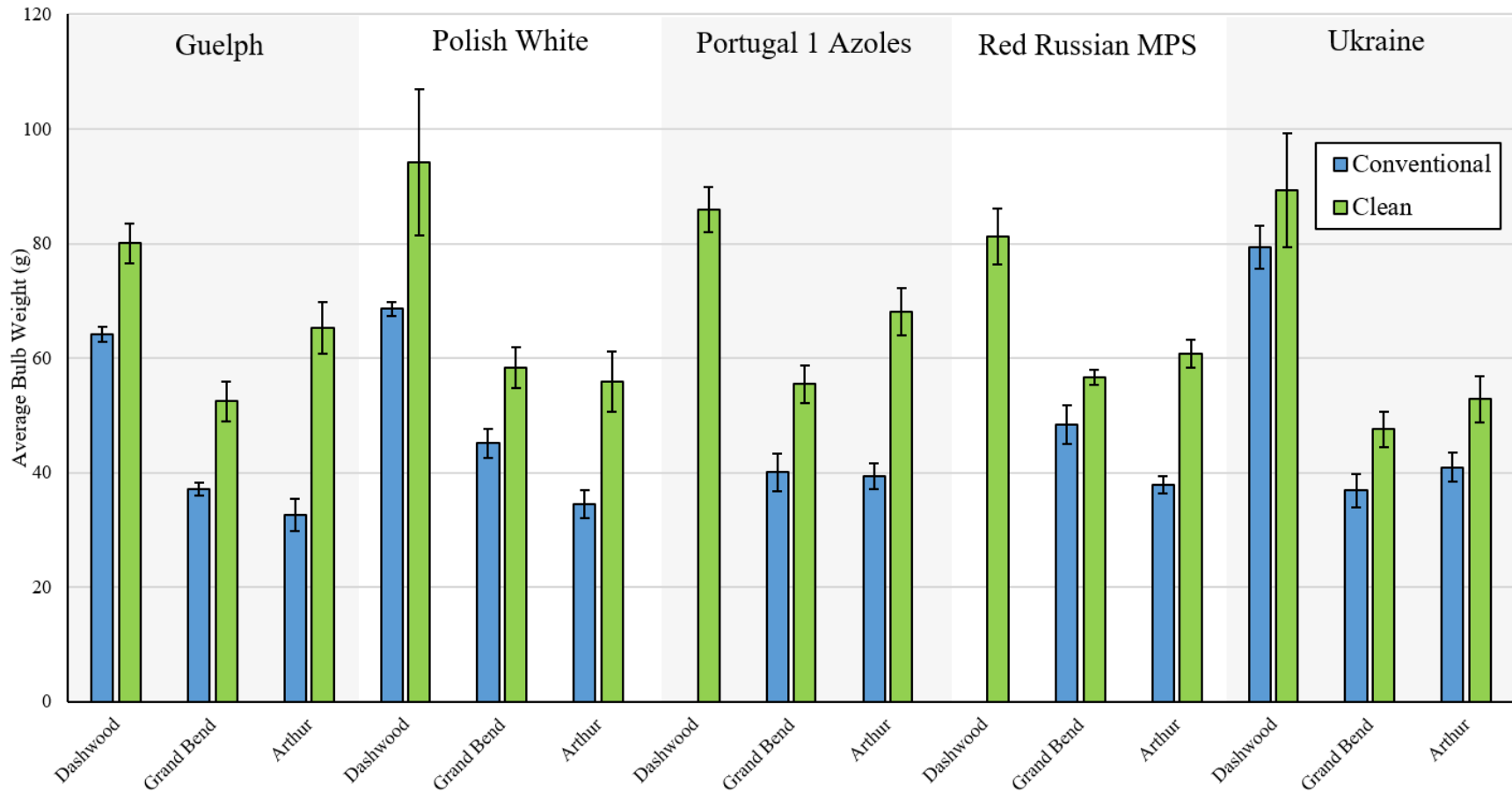
<sup>2</sup> Numbers in a column followed by the same letter are not significantly different at  $P = 0.05$  or among cultivars at each location.

<sup>3</sup> Clove Weight at Planting (CWP) was equal for each replication and the Bulb to Clove Ratio is based on the CWP. With no difference in the CWP means, they are unable to be separated using Tukey-Kramer multiple mean comparison test.

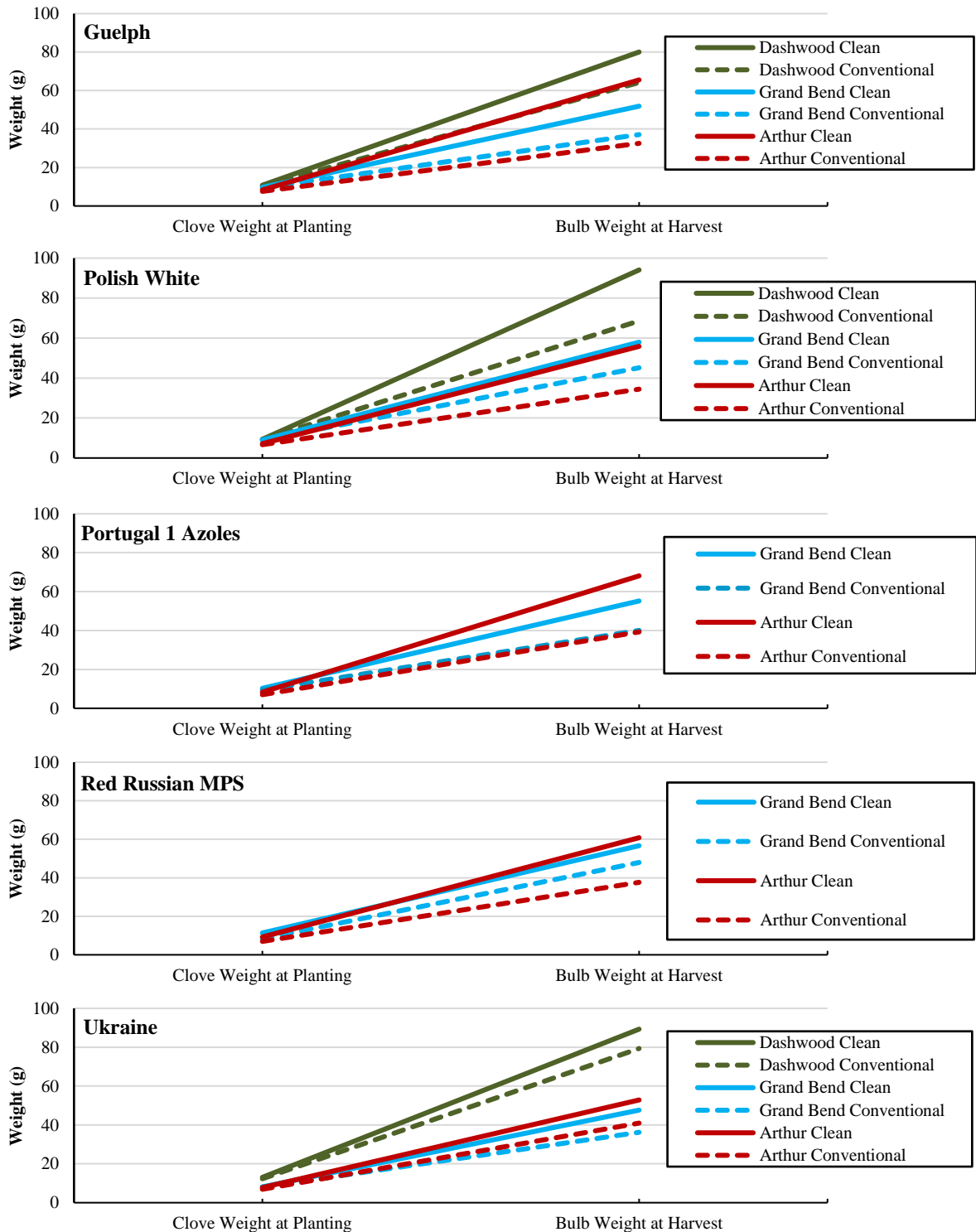
<sup>4</sup> Conventional to Clean percentage increased was based on the cured bulb weight in 2025.

<sup>5</sup> MPS = Marbled Purple Stripe.

<sup>6</sup> Planting density at Dashwood was approximately ~65k plants per acre whereas at Grand Bend the planting density was ~170k plants per acre and Arthur was ~80k plants per acre. All plants were grown in an adjacent field in 2023–2024 field season except for the Arthur plants which were cloves that were grown from the Grand Bend field site.



**Figure 3.** Average bulb weights of Guelph, Polish White, Portugal 1 Azoles, Red Russian MPS and Ukraine from the Clean Seed Program as well as their conventional counterparts grown in Dashwood, Grand Bend and Arthur during the 2024–2025 field season. Planting density at Dashwood was approximately ~65k plants per acre whereas at Grand Bend the planting density was ~170k plants per acre and Arthur was ~150k plants per acre. All plants were grown in an adjacent field with the same soil type in the 2023–2024 field season except for the Arthur plants which were cloves that were grown from the Grand Bend field site.



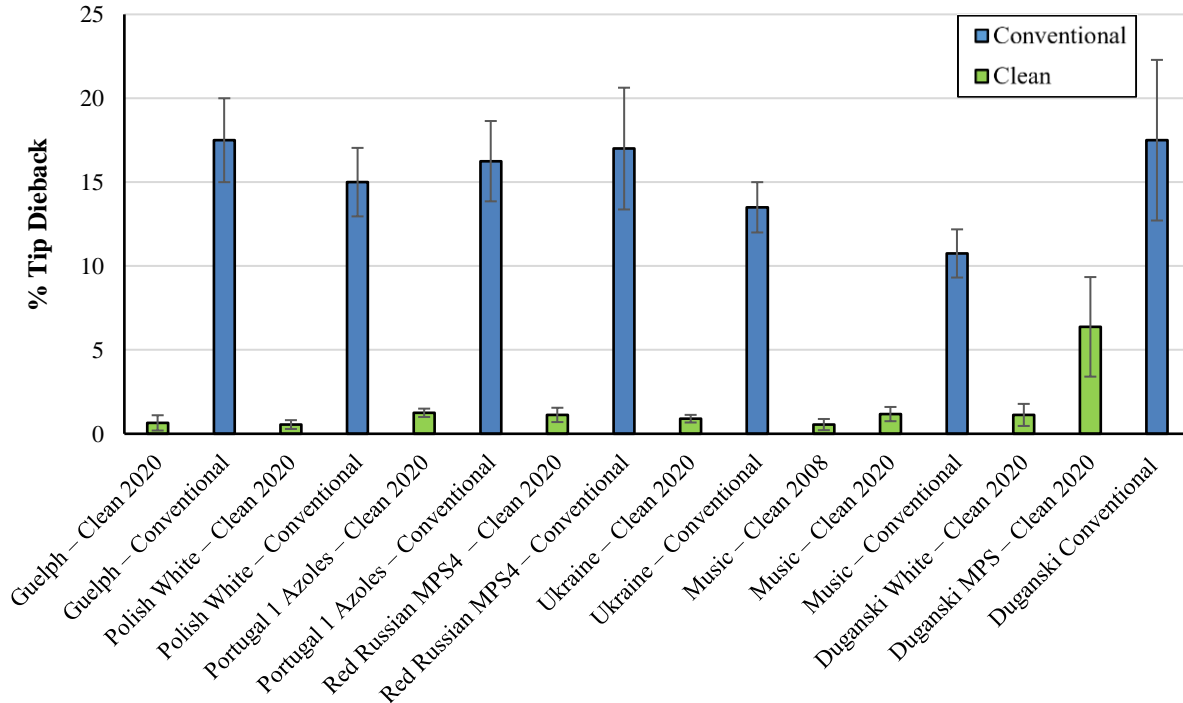
**Figure 4.** Clove and cured bulb weights of Guelph, Polish White, Portugal 1 Azoles, Red Russian MPS and Ukraine from the Clean Seed Program (CSP) as well as their conventional counterparts grown in Dashwood, Grand Bend and Arthur during the 2024–2025 field season. Planting density at Dashwood was approximately ~65k plants per acre whereas at Grand Bend the planting density was ~170k plants per acre and Arthur was ~150k plants per acre. All plants were grown in an adjacent field in the 2023–2024 field season except for the Arthur plants which were cloves that were grown from the Grand Bend field site.

**Table 2.** Average tip dieback as a percentage of brown or yellow leaves relative to the entire plant observed at the Arthur field site 4 June 2025.

Location	Cultivar	% Tip Dieback
Arthur	Guelph – Clean 2021	0.7 b
	Guelph – Conventional	17.5 a
	Polish White – Clean 2021	0.6 b
	Polish White – Conventional	15.0 a
	Portugal 1 Azoles – Clean 2021	1.3 b
	Portugal 1 Azoles – Conventional	16.3 a
	Red Russian Marbled Purple Stripe – Clean 2021	1.1 b
	Red Russian Marbled Purple Stripe – Conventional	17.0 a
	Ukraine – Clean 2021	0.9 b
	Ukraine – Conventional	13.5 a
	Music – Clean 2008	0.6 b
	Music – Clean 2021	1.2 b
	Music – Conventional	10.8 a
	Duganski White – Clean 2021	1.1 b
	Duganski Marbled Purple Stripe – Clean 2021	6.4 ab
	Duganski Marbled Purple Stripe – Conventional	17.5 a

<sup>1</sup> All treatments had four replications.

<sup>2</sup> Numbers in a column followed by the same letter are not significantly different at  $P = 0.05$  or among cultivars at each location.



**Figure 5.** Average tip dieback as a percentage of brown or yellow leaves relative to the entire plant observed at the Arthur field site 4 June 2025. Minor tip dieback was observed at the Dashwood site and little to no tip dieback was observed at the Grand Bend site in 2025.