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RESEARCH

Evaluation of Pumpkin (*Cucurbita* spp.) Accessions for Morphological and Yield Characteristics, and Resistance to Viral Diseases in Sri Lanka

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ABSTRACT

Pumpkin (*Cucurbita* spp.) is a vital crop in Sri Lanka due to its nutritional and economic significance. Pumpkins are vulnerable to diverse viral infections, often resulting in substantial yield and quality losses. The present study was conducted at Onesh Agri (Pvt) Ltd.'s farm in Thanamalwila (DL1 b), Sri Lanka. The study aimed to evaluate the viral disease resistance and morphological traits including number of laterals per vine, time to first female flower, leaf length and width and yield traits, including days to commercial harvest, number of fruits per vine, weight of fruit, fruit length and breadth of 60 pumpkin accessions developed by the World Vegetable Center, Taiwan, under local environmental conditions. The experiment followed a Randomized Complete Block Design (RCBD) with border rows planted with the virus-susceptible F1 variety Suprema as a control. Based on their quantitative traits, hierarchical cluster analysis grouped tested accessions into two major cluster groups, comprising 23 and 34 accessions in groups 1 and 2, respectively. Among these, 11 accessions namely, PUMP003, PUMP009, PUMP017, PUMP019, PUMP023, PUMP026, PUMP030, PUMP033, PUMP034, PUMP043, and PUMP047 demonstrated partial resistance to common viral diseases. Notably, PUMP017 (36.5±1.18) was identified as early flowering, while PUMP033 (62.0±1.95) early fruiting. The PUMP026 (5.6±0.48) produced the highest number of fruits per vine, and PUMP030 (4121.0±195.98 g) yielded the heaviest fruits with favorable fruit dimensions and flesh thickness. These findings provide valuable insights for future pumpkin breeding programs aimed at developing new varieties with enhanced resistance to viral diseases in the Sri Lankan context.

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INTRODUCTION

Pumpkins are cultivated worldwide, and commonly grown species include *Cucurbita maxima, Cucurbita moschata, Cucurbita pepo, Cucurbita mixta, and Cucurbita ficifolia* (Dhiman et al., 2009; Hussain et al., 2017). Among these species, *C. maxima* holds the distinction of being the earliest species domesticated in South America, with a history of human consumption spanning over 12,000 years (Castellanos-Morales et al., 2019). Pumpkins are nutritionally valuable, rich in essential vitamins (A, C, E, and B vitamins) and minerals (potassium, magnesium, and manganese), which contribute to their numerous health benefits (Bhat and Bhat, 2013). Additionally, pumpkins contain high levels of antioxidants such as carotenoids, flavonoids, and phenolic compounds, which help combat free radicals and protect against certain cancers and cardiovascular diseases (Stryjecka et al., 2023). Moreover, pumpkin provides dietary fiber, which supports a healthy digestive system, blood sugar regulation, and satiety (Uduwerella et al., 2021).

In Sri Lanka, pumpkin cultivation takes place during both the *Yala* and *Maha* seasons, with the *Maha* season being more prominent due to favorable climatic conditions (Pushpakumari et al., 2013). Cultivation is widespread across the dry and intermediate zones of the island, typically in areas with elevations of approximately 500 m (Ruwanthika et al., 2023). Improved hybrid varieties have demonstrated a 30% higher yield compared to local traditional varieties (Kandel, 2020). Consequently, farmers in Sri Lanka prefer to grow imported F1 hybrids such as Arjuna, Raja, and Lara, among others (Darshani et al., 2021) due to heterosis (hybrid vigor), F1 hybrids often exhibit superior performance. However, these F1 hybrids are highly susceptible to virus diseases, leading to substantial yield losses within a few years after their introduction.

Viral infections continue to be a major issue for Cucurbit crops, causing substantial reductions in both yield and quality during outbreaks (Radouane et al., 2021). Cucurbit crops are known to host around 90 virus species from various families, such as Bromoviridae, Closteroviridae, Geminiviridae, Potyviridae, Solemoviridae, Tospoviridae, and Virgaviridae (Lecoq, 2003). Among viral pathogens affecting pumpkins, Cucumber Mosaic Virus (CMV) is one of the most economically significant due to its wide host range, rapid transmission by aphids, and ability to persist in weed reservoirs. CMV belongs to the genus Cucumovirus in the family Bromoviridae and has been reported to infect over 1,000 plant species, including cucurbits, solanaceous crops, and legumes (Lecoq and Katis, 2014). The virus causes severe symptoms such as mosaic patterns, leaf distortion, stunting, and fruit malformation, leading to reduced yield and marketability (Shehata et al., 2023). In Sri Lanka, CMV has been identified as a major constraint in pumpkin production, with reported yield losses ranging from 30% to 70%, depending on the severity of the infection, crop variety, and environmental conditions (Nagendran et al., 2017).

The management of CMV and other cucurbit viruses relies on three key strategies: planting healthy seeds or seedlings in a clean environment, disrupting vector activity, and deploying virus-resistant cultivars (Lecoq and Katis, 2014). The use of disinfected seeds and disease-free seedlings is essential to prevent initial infections, while vector control measures such as insecticides, mineral oils, and reflective mulches can reduce virus transmission in the field (Díaz Nájera et al., 2020). However, the most sustainable and long-term approach for virus management is the development of resistant cultivars through breeding programs. Grafting onto resistant rootstocks, cross-protection, conventional breeding, and genetic engineering are potential strategies to enhance resistance against CMV and other viral pathogens.

Given the increasing prevalence of viral diseases in pumpkin-growing regions of Sri Lanka and their devastating impact on yield, there is an urgent need to develop F1 hybrid pumpkin varieties with durable resistance to viral diseases while maintaining desirable agronomic and market traits. Therefore, the present study aims to evaluate advanced Cucurbita breeding lines for field resistance to viral diseases, along with their vegetative and reproductive traits, to identify potential germplasm for future F1 hybrid development under local conditions.

MATTERIALS AND METHODS

The experiment was conducted at the Onesh Agri (PVT) Ltd. farm in Thanamalwila (6.4479° N, 81.1446° E), located in the Uva Province of Sri Lanka, which falls within the DL1b agro-ecological zone, during the *Maha* season 2023/2024. Sixty pumpkin accessions, developed by the World Vegetable Center (AVRDC), Taiwan, were used for this study. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replicates. To induce virus infection, border rows were planted with the virus susceptible commercial variety, Suprema F1. Seedlings were first raised in a nursery for two weeks, and healthy plants were then transplanted into the field with a spacing of 1.5 m x 4 m. Fertilization was carried out following the Department of Agriculture (DoA) recommendations for Sri Lanka, and weeding was done as necessary. The vines were trained to promote effective pollination and prevent entanglement, allowing for the clear identification of each vine. Pesticides were applied according to DoA guidelines during the early growth stages, and pheromone traps were installed to manage fruit fly infestations.

Then accessions were rigorously evaluated for the vegetative, reproductive and yield traits, which include 17 quantitative and 42 qualitative traits according to the AVRDC – GRSU crop descriptor (Cucurbita, 2015) of the Asian Vegetable Research and Development Center (AVRDC). The vegetative traits included, length of the main vine, number of laterals per vine, leaf length and width, leaf petiole length, leaf peduncle length and corolla diameter, reproductive and yield traits included, time to first female flower, days to commercial harvest, number of fruits per vine, weight of fruit, fruit length and breadth, fruit color intensity, leaf pubescence density, fruit surface, flesh thickness, flesh flavor-steamed, and flesh texture-steamed.

Meantime virus susceptibility score of the pumpkin accessions were measured using the following scale (Seda-Martínez et al., 2021).

A score of 0 indicated no visible virus symptoms, while a score of 1 corresponded to the presence of a few flecks or lesions or very mild mottle. A score of 2 denoted numerous lesions or a strong mosaic or mottle. A score of 3 represented a strong mosaic or mottle accompanied by some large lesions or blisters. At score 4, plants exhibited strong mosaic or mottle with many large lesions or blisters, along with slight to moderate leaf deformation. The highest score, 5, indicated severe blistering with pronounced leaf deformation, including serrated edges or strapped leaves.

Statistical analysis

The SPSS statistical package (version 25) was used for the following data analysis. A cluster analysis was done for quantitative traits to identify similar accessions. Among the tested pumpkin accessions, eleven virus resistant were used for further analysis of their vegetative, reproductive and yield traits. One-way ANOVA followed by Tukey post hoc test was used to analyze quantitative characters, while qualitative morphological characters were examined by the Friedman test.

RESULTS AND DISCUSSION

According to hierarchical cluster analysis to identify diversity of pumpkin accessions based on their vegetative and reproductive traits, two primary cluster groups (Group 1 and 2) were observed at the 23.47 dissimilarity level and each cluster was divided into two sub-cluster groups higher than 7.81 dissimilarity level. The group 1 encompasses two sub-clusters, totaling 23 accessions. the first sub-cluster, comprising 17 accessions (PUMP001, PUMP005, PUMP024, PUMP056, PUMP060, PUMP061, PUMP008, PUMP015, PUMP030, PUMP021, PUMP029, PUMP046, PUMP011, PUMP032, PUMP050, PUMP025, and PUMP048), shares more pronounced similarities in characteristics such as leaf length and width, as well as fruit skin and flesh thickness. In contrast, the second sub-cluster consists of two distinct groups, totaling six accessions, PUMP036, PUMP045, PUMP052, PUMP057, PUMP058, and PUMP059. These accessions within the sub-cluster exhibit deviations from others in terms of leaf length, leaf width, number of days to commercial maturity for harvest, fruit weight, and flesh thickness. Cluster group 2, consisted of 34 accessions distributed across 02 primary sub-clusters. The first sub-cluster consisted of 14 accessions (PUMP002, PUMP003, PUMP053, PUMP026, PUMP040, PUMP051, PUMP009, PUMP014, PUMP028, PUMP019, PUMP037, PUMP055, PUMP038, and PUMP039), exhibiting high similarity in characteristics such as the number of laterals, leaf dimensions (length and width), corolla diameter, fruit skin and flesh thickness, main vine diameter, and days to first female flower. The second sub-cluster encompassed 20 accessions (PUMP002, PUMP003, PUMP007, PUMP009, PUMP010, PUMP013, PUMP014, PUMP016, PUMP017, PUMP020, PUMP023, PUMP026, PUMP027, PUMP028, PUMP031, PUMP033, PUMP034, PUMP035, PUMP040, PUMP041, PUMP042, PUMP043, PUMP044, PUMP047, PUMP049, PUMP051, PUMP053, and PUMP054). These accessions displayed similar traits, including petiole length, days to first female flower, days to commercial harvesting maturity, peduncle length, fruit flesh thickness, fruit breadth, leaf dimensions, and corolla diameter (Figure 1). These clustering results can reveal genetic relationships among different breeding lines, allowing breeders to select diverse and superior parents for future hybrid development.

As per the results, most of the pumpkin accessions were prone to viral diseases during their reproductive growth stage. The virus symptoms were primarily observed 60 days after planting on leaves and apical buds of these accessions. however, some accessions showed early symptoms due to their high susceptibility. Based on their virus susceptibility scores (below 2), 11 accessions were identified as resistant to viruses and subsequently selected for further analysis (Table 1).

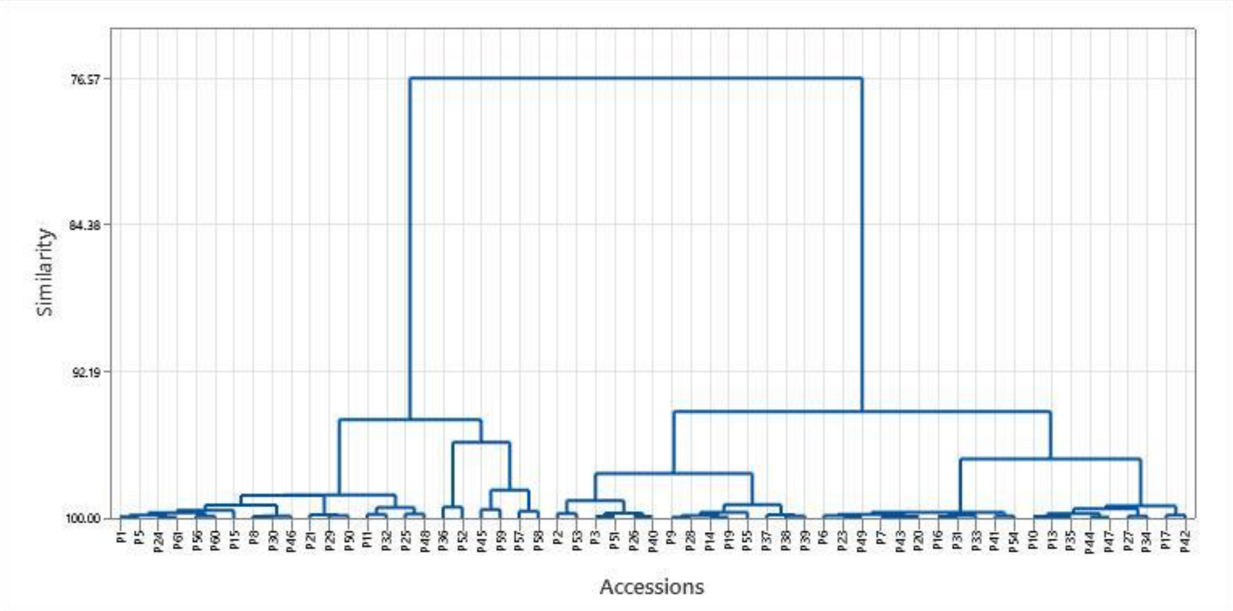

Figure 1: Cluster grouping of 57 Cucurbita spp., ward linkage, correlation coefficient distance method

(*Note: P denotes PUMP)

Table 1: Virus susceptibility score of evaluated pumpkin (*Cucurbita* spp.) accessions

Accessions	Mean VSS	Symptoms				DAP	Accessions	Mean VSS	Symptoms				DAP
		L	ApB	AuB	Frt				L	ApB	AuB	Frt	
PUMP001	4.00	+	+	+		20, 60	PUMP032	3.75	+	+	+		40, 60
PUMP002	3.50	+	+	+		60	**PUMP033**	**1.00**	**+**				**60**
PUMP003	**1.50**	**+**	**+**			**60**	**PUMP034**	**1.00**	**+**				**60**
PUMP004	2.62	+	+	+		60	PUMP035	2.60	+	+			60
PUMP005	2.37	+	+		+	60	PUMP036	2.50	+	+	+		60
PUMP006	3.62	+	+	+		60	PUMP037	2.80	+	+	+		60
PUMP007	2.25	+	+			60	PUMP038	4.12	+	+	+		60
PUMP008	2.75	+	+	+		60	PUMP039	3.33	+	+	+		40, 60
PUMP009	**1.62**	**+**	**+**	**+**	**+**	**60**	PUMP040	2.00	+	+	+		60
PUMP010	2.12	+	+	+		60	PUMP041	3.50	+	+	+		60
PUMP011	4.12	+	+	+		60	PUMP042	2.20	+	+	+		60
PUMP012	3.00	+	+	+		60	**PUMP043**	**1.57**	**+**				**60**
PUMP013	2.50	+	+	+		60	PUMP044	2.75	+	+	+		60
PUMP014	3.00	+	+	+		60	PUMP045	2.00	+				60
PUMP015	2.75	+	+	+		60	PUMP046	3.16	+	+	+	+	60
PUMP016	2.87	+	+	+	+	60	**PUMP047**	**1.50**	**+**				**60**
PUMP017	**1.62**	**+**	**+**	**+**		**60**	PUMP048	3.87	+	+	+	+	20, 60
PUMP019	**1.87**	**+**	**+**			**60**	PUMP049	2.75	+	+	+		60
PUMP020	3.50	+	+	+		60	PUMP050	3.25	+	+	+		60
PUMP021	2.62	+	+	+		60	PUMP051	4.00	+	+	+		60
PUMP022	3.50	+	+	+		40, 60	PUMP052	3.00	+	+			60
PUMP023	**1.87**	**+**	**+**	**+**		**60**	PUMP053	2.75	+	+	+		60
PUMP024	2.25	+	+	+		40, 60	PUMP054	2.87	+	+	+		60
PUMP025	2.87	+	+	+		40, 60	PUMP055	3.00	+	+	+		60
PUMP026	**1.62**	**+**	**+**			**60**	PUMP056	3.00	+	+	+		60
PUMP027	3.75	+	+	+		60	PUMP057	4.00	+	+	+		60
PUMP028	3.75	+	+	+		60	PUMP058	2.00	+	+	+		60
PUMP029	2.50	+	+	+		60	PUMP059	2.57	+	+	+		60
PUMP030	**1.50**	**+**				**60**	PUMP060	3.25	+	+	+		20, 40, 60
PUMP031	2.25	+	+	+		60	PUMP061	2.66	+		+		60

*Note: VSS= Virus susceptible score (0= No virus symptoms, 1= Few flecks or lesions /very mild mottle, 2= Numerous lesions/ Strong mosaic or mottle, 3= Strong mosaic mottle with some large lesions or blisters, 4= Strong mosaic or mottle with many large lesions or blisters and slight to moderate leaf deformation, 5= Severe blistering with strong leaf deformation including serrated edges or strapped leaves): L= Leaf, ApB= Apical bud, AuB = Axillary bud, Frt = fruits, DAP = Days after planting. Bold color letters indicate identified virus resistant accessions.

Vegetative and flowering traits

The virus resistant pumpkin accessions demonstrated significant variation in their vegetative and flowering traits, as presented in Table 2. The number of laterals per vine varied significantly between accessions ($F_{(10,75)} = 10.75$, $p<0.05$), ranging from 2.42±0.28 to 5.25±0.26. Notably, the highest number of laterals was recorded for PUMP033 (4.7±0.28), PUMP023 (4.7±0.26), and PUMP003 (4.10±0.24), respectively. In terms of leaf dimensions, the longest and widest leaves were observed for PUMP030, measuring 23.70±0.53 cm in length and 22.90±0.51 cm in width. Conversely, the smallest leaf dimensions were recorded for PUMP033, with leaf length and width measuring 15.50±0.61 cm and 16.0±0.60 cm, respectively. The observed variations in the number of laterals per vine and leaf area suggest a broad genetic base among the accessions. These parameters are crucial for light interception, photosynthetic efficiency, and overall plant vigor, which directly influence biomass accumulation and yield potential (Duursma et al., 2012). Previous studies have indicated that larger leaf area contributes to higher carbon assimilation, thereby enhancing vegetative growth and stress adaptability (Zhang et al., 2024).

Early flowering genotypes could be beneficial for breeding programs targeting short-duration crops suitable for specific climatic regions, especially under changing environmental conditions (Hosen et al., 2021). Moreover, it can reduce the extra costs associated with vine maintenance in the field and help mitigate the risks posed by adverse weather conditions. Regarding flowering time, PUMP003 required the longest time to produce the first female flower (54.9±1.10 days), whereas the earliest flowering was observed in PUMP017 (36.5±1.18 days). However, there was a statistically significant difference between the remaining accessions ($F_{(10,74)} = 10.74$, $p<0.05$).

Yield traits

The days to commercial harvesting was determined when 50% of the fruits displayed ash formation on the surface of the skin. According to the results, a significant difference was noted among the tested accessions ($F_{(10,37)} = 10.37$, $p<0.05$) for days taken to commercial harvest, with PUMP033, which exhibited the shortest duration, 62.00±1.94 days, compared to the remaining accessions (Table 3). The number of fruits per vine also showed a significant difference between the accessions ($F_{(10,71)} = 10.71$, $p<0.05$) and the highest number of fruits were obtained from PUMP026 (5.6±0.48), PUMP047 (5.3±0.55), PUMP034 (4.6±0.61), and PUMP023 (4.0±0.51). The mean fruit weight varied significantly between the accessions ($F_{(10,38)} = 10.38$, $p<0.05$), and the heaviest fruits were observed in PUMP030 (4121.00±195.98 g), PUMP019 (4014.30±195.98 g), and PUMP003 (3376.00±77.16 g). Similarly, fruit length also showed a significant difference between the accessions ($F_{(10,37)} = 10.37$, $p<0.05$) and it ranged between 8.84±0.77 – 29.67±0.77 cm and fruit breadth ranged between 13.70±1.13 to 25.96±1.10 cm. Well-sized fruits with an optimal length and breadth ensure a good harvest that is suited for consumption or for processing into various products. The significant differences in fruit weight, fruit number per plant, and total yield highlight the presence of promising high-yielding accessions. High-yielding accessions are particularly valuable for commercial production, as they align with farmer and consumer preferences and market demands for large, uniform fruits (Brdar et al., 2019). Previous research on *Cucurbita* spp. has demonstrated a trade-off between fruit size and total yield, where higher fruit number per plant often leads to reduced individual fruit weight, necessitating a balance between these traits in breeding efforts (Hosen et al., 2021). Additionally, accessions exhibiting uniform fruit shape and size offer market advantages due to better post-harvest handling, reduced transportation losses, and enhanced consumer appeal (Pokhrel, 2021). Yield stability is also a crucial consideration, as environmental factors such as temperature and soil fertility significantly influence fruit development and productivity (Seymen et al., 2021).

Table 2: Vegetative traits of the pumpkin (*Cucurbita* spp.) accessions with virus resistance

Accessions	Number of laterals per vine	Leaf Length (cm)	Leaf Width (cm)	Time to the first female flowers (Days)
PUMP003	4.1±0.24^{abc}	15.9±0.52^{d}	16.7±0.51^{bc}	54.9±1.10^{a}
PUMP009	3.4±0.26^{bc}	16.8±0.56^{cd}	16.9±0.55^{bc}	48.5±1.18^{bc}
PUMP017	3.7±0.26^{abc}	18.9±0.56^{bc}	19.2±0.55^{b}	36.5±1.18^{f}
PUMP019	3.9±0.24^{abc}	17.4±0.52^{bcd}	17.0±0.51^{bc}	44.5±1.10^{cd}
PUMP023	4.7±0.26^{a}	19.7±0.56^{b}	19.0±0.59^{b}	42.4±1.18^{de}
PUMP026	3.4±0.24^{c}	15.6±0.52^{d}	16.7±0.51^{bc}	50.5±1.10^{ab}
PUMP030	3.5±0.24^{abc}	23.7±0.52^{a}	22.8±0.51^{a}	43.4±1.18^{cd}
PUMP033	4.7±0.28^{ab}	15.5±0.61^{d}	16.0±0.59^{c}	37.0±1.28^{ef}
PUMP034	3.8±0.31^{abc}	19.2±0.66^{bc}	19.2±0.65^{b}	40.9±1.40^{def}
PUMP043	3.5±0.28^{abc}	19.4±0.61^{bc}	18.5±0.59^{bc}	43.7±1.28^{cd}
PUMP047	3.0±0.28^{c}	17.8±0.60^{bcd}	19.3±0.59^{b}	41.2±1.27^{def}
F value$_{(df)}$	75$_{(10)}$	75$_{(10)}$	74$_{(10)}$	74$_{(10)}$
P value	0.00	0.00	0.00	0.00

*Note: The values are means of each quantitative parameter ± standard error mean (SEM). The superscript with different letters indicates significant differences among accessions at a 5 % significant level based on a one-way ANOVA with Tukey's Post hoc test for selected accessions.

Table 3: Reproductive traits of the pumpkin (*Cucurbita* spp.) accessions

Accessions	Number of days to commercial harvesting	Number of fruits per vine	Weight of fruit (g)	Fruit length (cm)	Fruit breath (cm)
PUMP003	74.5±1.95^{a}	2.2±0.68^{cd}	3376.0±277.16^{a}	8.1±1.10^{g}	23.7±1.11^{a}
PUMP009	79.0±3.94^{a}	3.0±0.51^{bcd}	1673.5±284.59^{bc}	15.8±1.13^{cd}	16.0±1.11^{c}
PUMP017	79.0±2.75^{a}	1.8±0.56^{d}	2169.5±277.16^{b}	11.4±0.77^{efg}	23.4±1.11^{a}
PUMP019	79.0±1.95^{a}	2.3±0.48^{cd}	4014.3±195.98^{a}	17.4±0.77^{bc}	23.8±0.77^{a}
PUMP023	80.5±1.95^{a}	4.0±0.51^{abcd}	2059.3±195.98^{b}	12.7±0.77^{def}	20.2±0.77^{abc}
PUMP026	78.0±1.95^{a}	5.6±0.48^{a}	2103.8±195.98^{b}	20.9±0.77^{b}	18.0±0.77^{bc}
PUMP030	81.0±1.95^{a}	3.4±0.51^{abcd}	4121.0±195.98^{a}	28.1±0.77^{a}	21.0±0.77^{ab}
PUMP033	62.0±1.95^{b}	2.6±0.51^{cd}	743.8±195.98^{c}	11.6±0.77^{efg}	11.7±0.77^{d}
PUMP034	76.7±2.26^{a}	4.6±0.61^{abc}	2198.8±195.98^{b}	15.5±0.77^{cde}	18.1±0.77^{bc}
PUMP043	74.5±1.95^{a}	3.3±0.51^{abcd}	1766.3±195.98^{bc}	13.5±0.77^{cdef}	18.5±0.77^{bc}
PUMP047	79.0±1.95^{a}	5.3±0.55^{ab}	1211.4±175.77^{bc}	10.5±0.77^{fg}	18.8±0.77^{bc}
F value$_{(df)}$	37$_{(10)}$	71$_{(10)}$	38$_{(10)}$	37$_{(10)}$	37$_{(10)}$
P value	0.00	0.00	0.00	0.00	0.00

*Note: The values are means of each quantitative parameter ± standard error mean (SEM). The superscript with different letters indicates significant differences among accessions at a 5% significant level based on a one-way ANOVA with Tukey's Post hoc test for selected accessions.

The flesh color showed a significant difference between the accessions ($\chi^2_{(df)} = 40_{(10)}$, $p < 0.001$) Specifically, PUMP017, PUMP019, PUMP023, and PUMP026 exhibited a light flesh color, while PUMP003, PUMP009, PUMP030, PUMP034, PUMP043, and PUMP047 displayed an intermediate flesh color. Only PUMP023 demonstrated a dark color flesh intensity. Eight accessions (PUMP003, PUMP009, PUMP017, PUMP019, PUMP023, PUMP026, PUMP043 and PUMP047) exhibited ridged fruit surfaces, while only three (PUMP030, PUMP033 and PUMP034) displayed a rough surface. According to sensory data, the fresh flesh flavor significantly varied between the accessions ($\chi2_{(df)} = 40_{(10)}$, $p < 0.001$) and five (PUMP009, PUMP017, PUMP034, PUMP043 and PUMP047) exhibited an insipid taste, five (PUMP003, PUMP019, PUMP003, PUMP019, PUMP026, PUMP030 and PUMP033) displayed an intermediate taste, while PUMP023 had a sweet taste. Taste of steamed flesh showed a significant difference between the accessions ($\chi^2_{(df)} = 40_{(10)}$, $p < 0.00$) and six (PUMP019, PUMP023, PUMP026, PUMP034, PUMP043 and PUMP047) of them were found to have an insipid taste, while four accessions (PUMP003, PUMP009, PUMP017 and PUMP030) exhibited an intermediate taste. When comparing the flesh taste in fresh and steamed conditions, notable differences were observed among the accessions, with some tastes not aligning between the two states. Moreover, most of the accessions (PUMP003, PUMP009, PUMP019, PUMP023, PUMP026, PUMP030, PUMP033 and PUMP043) were characterized by a soft texture at their fresh form, with a significant difference noted between the accessions ($\chi^2_{(df)} = 40_{(10)}$, $p < 0.001$). Nevertheless, steamed pumpkins, five accessions displayed a grainy texture (PUMP017, PUMP019, PUMP023, PUMP026 and PUMP034), while four accessions exhibited a soft texture (PUMP003, PUMP009, PUMP030 and PUMP033). Similarly, a significant difference was observed between the accessions in this context as well ($\chi^2_{(df)} = 44_{(10)}$, $p < 0.001$). Once again, there were a notable disparity in texture between the fresh and steamed flesh (Table 4.).

Table 4: Qualitative characters of the main vine, sensory evaluated traits and fruits of the pumpkin accessions

Accessions	Fruit color intensity	Length of the main vine	Leaf pubescence density	Fruit surface	Flesh flavor-steamed	Flesh texture-steamed
PUMP003	Intermediate	Medium	Intermediate	Smooth	Intermediate	Soft
PUMP009	Intermediate	Long	Intermediate	Smooth	Intermediate	Soft
PUMP017	Light	Long	Sparse	Smooth	Intermediate	Grainy
PUMP019	Light	Long	Intermediate	Smooth	Insipid	Grainy
PUMP023	Light	Long	Intermediate	Smooth	Insipid	Grainy
PUMP026	Light	Long	Dense	Smooth	Insipid	Grainy
PUMP030	Intermediate	Long	Dense	Rough	Intermediate	Soft
PUMP033	Dark	Medium	Sparse	Rough	Intermediate	Soft
PUMP034	Intermediate	Long	Sparse	Rough	Insipid	Grainy
PUMP043	Intermediate	Long	Sparse	Smooth	Insipid	Fibrous
PUMP047	Intermediate	Long	Sparse	Smooth	Insipid	Fibrous
$\chi^2_{(df)}$	$40_{(10)}$	$32.5_{(10)}$	$39.187_{(10)}$	$40_{(10)}$	$40_{(10)}$	$44_{(10)}$
P	0.000	0.000	0.000	0.000	0.000	0.000

*Note: Each cell represents the character of median value (n=11)

CONCLUSIONS

The present study identified 11 from a pool of 60 pumpkin accessions which are partially resistant (susceptible score <2) to common viral diseases (PUMP003, PUMP009, PUMP017, PUMP019, PUMP023, PUMP026, PUMP030, PUMP033, PUMP034, PUMP043, and PUMP047). As per the morphological and yield characteristics, PUMP017 recorded a short duration for flowering. However, PUMP047 and PUMP033 were identified as short-duration accessions as need less days to commercial harvesting. Despite the fact that PUMP026 yielded the superior number of fruits per vine and PUMP030 excelled in fruit length, breadth, and flesh thickness. In addition, PUMP030 emerged as the accession with the highest genotypic potential across a majority of morphological and yield characteristics, such as desirable flesh taste and texture. Hence, desirable traits of these accessions could be used for future pumpkin breeding programs to develop new pumpkin varieties that are resistant to viral diseases.

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