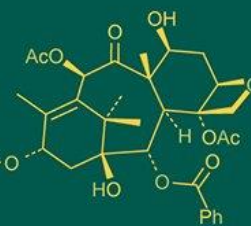
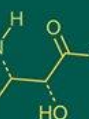
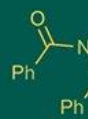


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Evaluation of *per se* performance of parents and F₁ hybrids for yield and quantitative traits in pumpkin (*Cucurbita moschata* L.)

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Abstract

The present investigation was carried out to evaluate the *per se* performance of parental genotypes and F₁ hybrids for yield and associated quantitative traits in pumpkin (*Cucurbita moschata* L.). The experiment was carried out at the Horticulture Research Centre, Department of Vegetable Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India, during the summers of 2022-2023 and 2023-2024, respectively. In a Randomized Block Design with three replications, fourteen genetically different parental genotypes (ten lines and four testers) and forty F₁ hybrids created by a line × tester mating design were assessed. Data were recorded on nineteen quantitative and yield-related traits including vine length, primary branches, flowering behavior, fruit diameter, fruit weight, number of fruits per plant, fruit yield per plant, total soluble solids and total yield.

Analysis of variance revealed significant differences among genotypes for all the characters studied, indicating the presence of substantial variability among parents and hybrids. Among the parents, Pumpkin-87 recorded the highest fruit yield per plant (26.81 kg) and total yield (35.94 t ha⁻¹), followed closely by Pumpkin V-4 (35.95 t ha⁻¹) and Pumpkin-73 (35.43 t ha⁻¹). Among the F₁ hybrids, Arka Suryamukhi × Pumpkin-73 exhibited the highest total yield (52.93 t ha⁻¹) and superior fruit yield per plant (28.77 kg). Other promising hybrids included Pusa Vikas × VPRK-310 (52.08 t ha⁻¹), Azad Pumpkin × Pumpkin-87 (43.41 t ha⁻¹), Arka Suryamukhi × Pumpkin LM-350 (43.88 t ha⁻¹), and Arka Suryamukhi × Narendra Agrim (41.83 t ha⁻¹). These hybrids also showed desirable performance for important yield-contributing traits such as fruit weight, number of fruits per plant, and fruit yield per plant.

Keywords: Pumpkin, F₁ hybrids, *Per se* performance, fruit yield, quantitative traits, hybrid evaluation

Introduction

Pumpkin (*Cucurbita moschata* Duch. ex Poir.) is a major cucurbitaceous vegetable crop grown in tropical and subtropical locations across the world. It is a member of the Cucurbitaceae family (2n = 2x = 40) and is widely produced because to its high production, great storage quality, capacity to adapt to a variety of agroclimatic conditions, and several culinary and nutritional purposes (Robinson and Decker-Walters, 1997) [12]. An commercially significant vegetable crop, pumpkin is widely grown in Asia, Africa, Europe, and the Americas. In India, it is grown during both rainy and summer seasons and contributes significantly to vegetable production due to its wide consumer acceptance and high market demand (Choudhury, 1996) [2].

It is well known that pumpkin fruits are a great source of bioactive compounds, vitamins, minerals, dietary fiber, and carbs. Along with vitamin C, vitamin E, potassium, calcium, phosphorus, and antioxidant chemicals that support human health, the fruit is especially rich in β-carotene, a crucial precursor of vitamin A (Paris, 2016) [11]. Pumpkin is a nutritionally exceptional vegetable crop, and the seeds are similarly useful since they include high-quality edible oil, proteins, unsaturated fatty acids, tocopherols, phytosterols, and various minerals (Kulczyński and Gramza-Michałowska, 2019) [7]. Pumpkin has become more and more important in the food processing sectors for the creation of soups, baked goods, infant meals, drinks, and nutraceutical items due to its high nutritional content and functional food value (Omar *et al.*, 2024) [9].

Despite its economic significance, pumpkin yield is still relatively low in many growing locations because local cultivars are genetically diverse, there are no better hybrids, and the genetic variability that is present is not fully used. Therefore, finding and using genetically superior parents and hybrids with desirable agronomic features is crucial for increasing yield and fruit quality. The selection of prospective breeding materials for agricultural improvement programs is based on the evaluation of parental genotypes and hybrids under field settings, which yields important information on their performance and adaptability (Acquaah, 2020) ^[1].

Since *per se* performance directly reflects the phenotypic expression of economically significant features under a particular environment, it is regarded as one of the most trustworthy criteria for assessing the genetic potential of parental lines and hybrids. Before they are used in breeding programs or suggested for commercial cultivation, breeders can discover top genotypes with greater production potential, fruit quality, and adaptability by evaluating *per se* performance. Superior *per se* performance of hybrids generally results from the favourable interaction of genes inherited from genetically diverse parents and is often reflected in enhanced vegetative growth, improved flowering behaviour, increased fruit set, larger fruit size, and higher fruit yield (Falconer and Mackay, 1996) ^[3]. Therefore, a crucial stage in hybrid breeding programs aiming at creating high-yielding cultivars is the rigorous assessment of parental lines and F₁ hybrids.

There is a lot of genetic diversity that can be successfully utilized through selection and hybridization, according to earlier research that showed significant variation among pumpkin genotypes for yield and related traits (Mohanty, 2000; Pandey *et al.*, 2010; Tamil Selvi *et al.*, 2013) ^[8, 10, 13]. Finding high-performing parental genotypes and F₁ hybrids suited to the agroclimatic conditions in northwest India is still a challenge, despite the fact that many research have examined hybrid performance in pumpkin. Additionally, assessing recently created hybrids for a variety of quantitative and yield-related characteristics is crucial for finding promising genotypes appropriate for both commercial production and future breeding initiatives. A thorough evaluation of *per se* performance helps breeders choose better genetic resources for creating better pumpkin cultivars and offers important information on the productive potential of individual parents and hybrids.

Therefore, the present investigation was undertaken to evaluate the *Per se* performance of fourteen parental genotypes and forty F₁ hybrids of pumpkin for nineteen quantitative and yield-related traits under field conditions. The study aimed to identify superior parental lines and promising hybrids exhibiting desirable agronomic performance and high yield potential for their effective utilization in future pumpkin improvement programmes.

Materials and Methods

Experimental site

The field experiment was conducted during the summer season of 2022-23 and 2023-24 respectively at the Horticulture Research Centre, Department of Vegetable Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India. The

experimental site is situated at 29°01' N latitude and 77.75° E longitude, at an elevation of approximately 297 m above mean sea level, representing the North Western Plain Zone of Uttar Pradesh.

Experimental materials

The experimental material consisted of fourteen genetically diverse pumpkin genotypes maintained at the Horticulture Research Centre of the university. These included ten lines, namely Kashi Harit, Pumpkin 21-81, VRPK-310, Narendra Agrim, Pumpkin-303, Pumpkin-87, Pumpkin-73, Pumpkin V-4, Pumpkin LM-350 and VRPK-07-01; and four testers, namely Pusa Vikas, Arka Suryamukhi, Arka Chandan and Azad Pumpkin. Forty F₁ hybrids were developed by crossing the ten lines with the four testers in a line × tester mating design during the preceding season. Thus, a total of fifty-four genotypes (14 parents + 40 F₁ hybrids) were evaluated in the present study.

Experimental design

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each replication contained all fifty-four genotypes, and the entries were randomized separately within each replication. The field was prepared to a fine tilth by repeated ploughing, harrowing, and planking. Well-decomposed farmyard manure at the rate of 20 t ha⁻¹ was incorporated into the soil during field preparation. Fertilizers were applied at the recommended dose of 100:60:80 kg N:P₂O₅: K₂O ha⁻¹. Half of the nitrogen along with the full doses of phosphorus and potassium was applied as basal, while the remaining nitrogen was top-dressed 30 days after sowing.

Seeds were soaked in water for 24 h prior to sowing to ensure uniform germination. After shade drying, the seeds were sown in well-prepared plots at a spacing of 3.0 m × 1.0 m and at a depth of approximately 2-3 cm. Standard agronomic practices including irrigation, weeding, hoeing, and plant protection measures were adopted uniformly for all treatments throughout the crop growth period.

Observations recorded

Observations were recorded on five randomly selected plants from each genotype in each replication for nineteen quantitative and yield-related traits, namely vine length, number of primary branches, days to first male and female flower initiation, number of male and female flowers per vine, sex ratio, fruit weight, fruit length, fruit diameter, fruit flesh thickness, days to first fruit set, number of fruits per plant, number of seeds per fruit, 100-seed weight, fruit yield per plant, days to first fruit harvest, total soluble solids (TSS) and total fruit yield per hectare.

Fruit weight was recorded using a digital balance, while fruit length, fruit diameter, and flesh thickness were measured using standard measuring instruments. TSS was determined from fresh fruit juice using a digital refractometer and expressed in °Brix. Total yield per hectare was calculated from fruit yield per plant and converted into tonnes per hectare.

Statistical analysis

The recorded data were subjected to analysis of variance (ANOVA) appropriate for the Randomized Block Design as

described by Panse and Sukhatme (1969). The significance of differences among genotypes was tested using the F-test at 5% and 1% probability levels. When significant differences were observed, treatment means were compared using the Critical Difference (CD) at the 5% level of significance.

Results and Discussion

Analysis of variance

The analysis of variance revealed highly significant differences among the evaluated genotypes for all nineteen quantitative characters, indicating the existence of considerable genetic variability among the parental lines and F_1 hybrids. The observed variability among genotypes indicated that the parental lines used in the hybridization programme were genetically diverse and produced hybrids with a wide range of phenotypic expressions. Similar observations regarding the existence of substantial variability among pumpkin genotypes have been reported by Mohanty (2000)^[1], Tamil Selvi *et al.* (2013)^[13], Hatwal *et al.* (2018)^[5], Ikbali *et al.* (2022)^[6] and Harshini *et al.* (2024)^[4].

Per se performance of parents

The fourteen parental genotypes exhibited considerable variation for all quantitative characters, reflecting their diverse genetic background. Such variation among the parents is advantageous for selecting suitable donor lines for hybrid development and future breeding programmes.

Among the parental lines, Pumpkin-87 emerged as the most promising genotype for fruit yield and associated characters. It recorded the highest fruit yield per plant (26.81 kg) and one of the highest total yields (35.94 t ha⁻¹). In addition, it produced the maximum number of primary branches (7.12), the highest number of female flowers per vine (8.70), desirable fruit weight (3.25 kg), and a higher number of fruits per plant (8.25), indicating its excellent yield potential.

Pumpkin V-4 also performed remarkably well, producing a total yield of 35.95 t ha⁻¹ with comparatively higher fruit yield per plant (21.56 kg), greater number of fruits per plant (6.25), and desirable fruit weight (3.45 kg). Similarly, Pumpkin-73 exhibited superior performance for fruit yield per plant (20.59 kg) and total yield (35.43 t ha⁻¹), together with relatively high fruit weight (4.16 kg) and a higher number of fruits per plant (4.95).

Among the remaining parental lines, Pumpkin-303 recorded the highest fruit yield per plant (17.67 kg) among medium-yielding parents and exhibited comparatively larger fruit size with fruit weight of 3.24 kg. VRPK-310 was another superior parent, producing fruit yield per plant of 14.55 kg and total yield of 23.43 t ha⁻¹. It also possessed desirable vine length (9.65 m), fruit weight (3.13 kg), fruit length (21.95 cm), and fruit diameter (12.67 cm), indicating its usefulness as a productive breeding parent.

Among the testers, Arka Suryamukhi performed better than the other testers, recording fruit yield per plant of 14.09 kg and total yield of 23.49 t ha⁻¹. The tester also produced comparatively thicker fruit flesh (3.65 cm), higher TSS (10.65 °Brix), and a greater number of seeds per fruit (185.32). Pusa Vikas showed desirable fruit weight (1.26 kg) and produced the highest number of fruits per plant (4.06) among the testers, whereas Arka Chandan was superior for fruit diameter (12.78 cm) and TSS (9.40 °Brix). The variability observed among the parental genotypes clearly demonstrated the presence of diverse agronomic characteristics, thereby providing an excellent opportunity for selecting elite parents possessing complementary traits. Parents such as Pumpkin-87, Pumpkin V-4, Pumpkin-73, Pumpkin-303, VRPK-310, and Arka Suryamukhi exhibited superior performance for yield and its component traits and may therefore serve as valuable genetic resources for future pumpkin breeding programmes.

Per se performance of F_1 hybrids

The forty F_1 hybrids exhibited wide variation for all quantitative and yield-related characters, demonstrating the effectiveness of hybridization in generating superior recombinants. Several hybrids significantly outperformed their respective parents for fruit yield and associated traits, indicating the potential of these cross combinations for commercial exploitation.

Among all the hybrids, Arka Suryamukhi × Pumpkin-73 recorded the highest total yield (52.93 t ha⁻¹) along with the highest fruit yield per plant (28.77 kg), making it the most promising hybrid in the present investigation. The superior performance of this hybrid was mainly attributed to its favourable expression for fruit weight, number of fruits per plant, and other yield-contributing characters.

The hybrid Pusa Vikas × VRPK-310 ranked second with a total yield of 52.08 t ha⁻¹ and exhibited excellent fruit yield per plant together with desirable fruit size and fruit weight. Similarly, Arka Suryamukhi × Pumpkin LM-350 recorded a total yield of 43.88 t ha⁻¹, while Azad Pumpkin × Pumpkin-87 produced 43.41 t ha⁻¹. Another promising hybrid, Arka Suryamukhi × Narendra Agrim, recorded a total yield of 41.83 t ha⁻¹ and showed superior performance for several yield-attributing traits. These hybrids may therefore be considered promising candidates for multilocation evaluation and possible commercial cultivation.

The superior performance of these hybrids may be attributed to the favourable combination of genes inherited from genetically diverse parents, resulting in better vegetative growth, efficient flowering, increased fruit set, larger fruit size, and ultimately higher fruit yield. Similar findings have been reported by Tamil Selvi *et al.* (2013)^[13], Hatwal *et al.* (2018)^[5], Ikbali *et al.* (2022)^[6], and Harshini *et al.* (2024)^[4], who also observed substantial variation in the performance of pumpkin hybrids and identified several high-yielding cross combinations.

Table 1: Mean performance of parents for 19 quantitative characters in Pumpkin (*Cucurbita moschata* L.)

Sl. No.	Parents	VL	PB	FFFI	FMFI	MFPV	FFPV	SR	FW	FL	FD	FFT	FFS	FPP	NSPF	HSW	FYPP	FFH	TSS	Yield (t/ha)
Lines																				
1	Kashi Harit	6.29	5.14	53.68	42.73	39.71	4.75	8.36	2.16	15.68	16.24	2.16	59.64	4.12	114.25	8.04	8.89	81.35	8.25	16.11
2	Pumpkin 21-81	8.35	4.25	72.35	68.95	34.65	3.75	9.24	2.68	14.65	8.95	2.75	77.15	3.25	169.25	6.15	8.71	91.35	8.77	14.02
3	VRPK-310	9.65	4.06	69.15	64.54	58.97	5.15	11.45	3.13	21.95	12.67	3.18	76.21	4.65	154.15	5.14	14.55	95.36	9.14	23.43
4	Narendra Agrim	6.14	4.42	47.21	39.52	33.02	3.10	10.64	2.14	20.14	11.76	1.95	53.17	2.65	129.14	6.45	5.65	84.25	9.45	7.72
5	Pumpkin-303	8.65	3.92	62.48	59.37	59.38	5.95	9.98	3.24	17.24	15.34	3.56	66.34	5.45	119.35	7.18	17.67	86.95	8.96	29.42
6	Pumpkin-87	10.24	7.12	68.27	62.35	127.71	8.70	14.68	3.25	16.87	18.24	2.48	72.18	8.25	189.37	7.77	26.81	87.25	10.12	35.94
7	Pumpkin-73	7.87	5.38	66.95	59.78	66.00	5.45	12.11	4.16	16.22	14.26	2.19	74.65	4.95	212.46	8.15	20.59	88.34	9.45	35.43
8	Pumpkin V-4	7.20	5.62	69.54	62.14	109.81	6.77	16.22	3.45	14.19	11.84	3.14	77.15	6.25	209.15	8.65	21.56	82.14	11.21	35.95
9	Pumpkin LM-350	6.85	4.98	70.27	64.67	58.51	4.35	13.45	3.95	19.65	15.19	2.21	75.89	3.75	198.65	5.49	14.81	80.65	9.78	25.15
10	VRPK-07-01	6.89	5.12	63.85	59.45	50.80	4.48	11.34	2.69	19.00	17.65	3.36	67.25	3.35	218.24	9.48	9.01	80.00	8.52	15.45
	Mean	7.81	5.00	64.37	58.35	63.86	5.24	11.75	3.09	17.56	14.22	2.70	69.96	4.67	171.40	7.25	14.82	85.76	9.36	23.86
Testers																				
1	Pusa Vikas	4.29	3.95	51.24	47.65	17.25	5.25	3.29	1.26	17.83	16.08	3.15	56.25	4.06	109.62	7.16	5.11	77.65	9.15	8.35
2	Arka Suryamukhi	4.02	4.65	63.00	51.00	30.95	10.25	3.00	1.75	18.75	16.25	3.65	67.15	8.05	185.32	6.25	14.09	71.24	10.65	23.49
3	Arka Chandan	3.85	4.25	57.25	50.25	39.95	4.56	8.76	2.15	17.89	12.78	2.95	62.18	3.94	136.57	5.76	9.80	79.15	9.40	16.22
4	Azad Pumpkin	6.87	7.12	56.52	48.35	41.68	3.40	12.26	1.89	8.35	9.69	2.63	58.65	2.98	171.26	6.14	5.63	81.24	11.45	9.29
	Mean	4.76	4.99	57.00	49.31	32.46	5.87	6.83	1.76	15.70	13.70	3.09	61.06	4.76	150.69	6.33	8.66	77.32	10.16	14.34
	Overall Mean	6.94	5.00	62.27	55.77	54.89	5.42	10.34	2.71	17.03	14.07	2.81	67.42	4.69	165.49	6.99	13.06	83.35	9.59	21.14
Range	Maximum	10.24	7.12	72.35	68.95	127.71	10.25	16.22	4.16	21.95	18.24	3.65	77.15	8.25	218.24	9.48	26.81	95.36	11.45	35.94
	Minimum	3.85	3.92	47.21	39.52	17.25	3.10	3.00	1.26	8.35	8.95	1.95	53.17	2.65	109.62	5.14	5.11	71.24	8.25	7.71
	SEm	0.21	0.12	2.38	1.69	2.27	0.19	0.39	0.13	0.62	0.43	0.07	2.97	0.24	5.36	0.28	0.85	2.17	0.34	0.30
	CD at 5%	0.60	0.36	6.93	4.91	6.61	0.55	1.13	0.37	1.79	1.26	0.21	8.63	0.70	15.59	0.81	2.47	6.30	0.98	0.87
	CV	5.15	4.27	6.63	5.25	7.17	6.05	6.53	8.23	6.26	5.35	4.38	7.63	8.83	5.61	6.92	11.26	4.51	6.06	2.46

VL = Vine Length (m), PB = Primary branches, FFFI = First female flower initiation, FMFI = First male flower initiation, MFPV = Male flower per vine, FFPV = Female flower per vine, SR = Sex ratio, FW = Fruit weight (Kg), FL = Fruit length (cm), FD = Fruit diameter (cm), FFT = Fruit flesh thickness (cm), FFS = First fruit set, FPP = Fruit per plant, NSPF = No. of seeds per fruit, HSW = 100 seed weight (g), FYPP = Fruit yield per plant (kg), FFH = First fruit harvest and TSS = TSS (brix).

Table 2: Mean performance of F₁s for 19 quantitative characters in Pumpkin (*Cucurbita moschata* L.)

Sl. No.	Crosses & Parents	VL	PB	FFFI	FMFI	MFPV	FFPV	SR	FW	FL	FD	FFT
1	Pusa Vikas x Kashi Harit	4.69	3.65	56.25	53.18	62.42	3.42	18.25	3.16	18.27	14.56	2.65
2	Arka Suryamukhi x Kashi Harit	6.72	7.21	62.35	57.46	36.94	3.12	11.84	3.42	14.35	16.24	2.56
3	Arka Chandan x Kashi Harit	4.95	3.35	52.65	49.25	113.41	5.12	22.15	3.45	15.17	16.53	3.82
4	Azad Pumpkin x Kashi Harit	7.99	4.05	59.35	46.25	41.15	3.15	13.06	4.19	15.24	12.35	2.44
5	Pusa Vikas x Pumpkin 21-81	4.95	3.31	59.59	54.54	72.77	3.79	19.20	2.95	20.58	16.67	3.48
6	Arka Suryamukhi x Pumpkin 21-81	4.69	6.51	56.48	52.66	40.86	2.86	14.29	4.76	15.65	16.85	3.18
7	Arka Chandan x Pumpkin 21-81	4.65	5.26	53.25	51.95	87.55	4.12	21.26	2.95	20.90	16.75	3.46
8	Azad Pumpkin x Pumpkin 21-81	8.45	4.16	53.42	48.95	66.24	3.98	16.64	3.73	15.89	14.36	2.65
9	Pusa Vikas x VRPK-310	7.25	3.60	54.39	49.65	149.14	7.95	18.76	4.95	19.65	18.89	3.28
10	Arka Suryamukhi x VRPK-310	7.14	8.31	60.24	54.21	66.03	4.91	13.45	4.34	15.14	17.24	3.38
11	Arka Chandan x VRPK-310	5.40	4.15	55.25	47.24	70.12	4.69	14.95	3.67	21.16	15.20	2.68
12	Azad Pumpkin x VRPK-310	5.95	4.69	55.69	47.62	58.45	5.65	10.35	4.62	16.14	11.65	2.98
13	Pusa Vikas x Narendra Agrim	5.12	4.95	61.45	54.15	92.32	4.95	18.64	3.95	17.44	15.25	2.43
14	Arka Suryamukhi x Narendra Agrim	8.85	5.89	52.35	45.35	61.91	6.95	8.90	5.71	19.95	18.95	3.46
15	Arka Chandan x Narendra Agrim	4.75	4.05	57.24	46.25	67.18	5.24	12.82	3.66	18.83	15.26	3.65
16	Azad Pumpkin x Narendra Agrim	4.36	3.08	73.25	67.25	43.67	2.65	16.48	3.16	17.22	15.86	3.14
17	Pusa Vikas x Pumpkin-303	8.95	3.15	62.34	55.26	117.43	6.10	19.25	4.25	18.35	14.18	2.85
18	Arka Suryamukhi x Pumpkin-303	5.65	6.31	62.39	55.93	26.23	2.71	9.68	5.01	18.45	18.65	3.72
19	Arka Chandan x Pumpkin-303	3.65	3.85	49.65	50.15	84.61	4.68	18.08	3.68	18.05	16.89	2.45
20	Azad Pumpkin x Pumpkin-303	5.64	3.23	59.15	49.58	49.65	4.16	11.94	3.79	17.10	15.34	2.69
21	Pusa Vikas x Pumpkin-87	8.04	4.26	53.89	47.58	103.77	5.15	20.15	3.74	18.12	14.65	3.15
22	Arka Suryamukhi x Pumpkin-87	6.71	6.73	67.15	61.13	47.55	4.19	11.35	4.17	14.95	14.26	3.63
23	Arka Chandan x Pumpkin-87	6.75	3.80	46.15	48.25	76.21	4.69	16.25	4.12	16.47	17.67	3.85
24	Azad Pumpkin x Pumpkin-87	5.28	5.35	59.84	53.14	68.95	5.79	11.90	4.84	15.69	12.36	3.48
25	Pusa Vikas x Pumpkin-73	4.65	3.15	57.65	52.15	70.96	3.98	17.83	4.12	18.35	14.65	3.05
26	Arka Suryamukhi x Pumpkin-73	6.44	8.00	57.24	47.33	80.20	5.64	14.22	5.62	16.34	15.96	4.69
27	Arka Chandan x Pumpkin-73	6.95	3.55	56.35	49.64	96.03	4.96	19.36	4.65	18.45	16.96	4.29
28	Azad Pumpkin x Pumpkin-73	7.45	4.74	54.55	48.65	76.14	4.16	18.30	3.76	15.67	11.69	3.77
29	Pusa Vikas x Pumpkin V-4	8.06	3.18	54.66	49.85	115.19	6.56	17.56	3.12	17.54	15.24	2.15
30	Arka Suryamukhi x Pumpkin V-4	4.98	5.49	66.98	59.21	45.41	3.81	11.92	2.96	16.11	15.05	3.86

31	Arka Chandan x Pumpkin V-4	4.98	3.14	49.65	50.35	116.73	6.15	18.98	4.12	17.65	15.25	3.83
32	Azad Pumpkin x Pumpkin V-4	4.12	3.74	58.31	48.94	64.21	4.65	13.81	3.85	14.24	14.55	2.45
33	Pusa Vikas x Pumpkin LM-350	7.17	3.15	56.15	45.62	110.23	6.39	17.25	3.45	18.21	15.02	2.65
34	Arka Suryamukhi x Pumpkin LM-350	5.23	7.42	71.24	65.35	45.00	3.75	12.00	7.65	17.85	12.67	4.38
35	Arka Chandan x Pumpkin LM-350	6.02	5.75	58.15	49.65	78.65	5.25	14.98	2.15	17.26	14.56	3.05
36	Azad Pumpkin x Pumpkin LM-350	6.25	4.04	59.14	53.65	69.15	4.24	16.31	3.97	13.85	14.25	2.69
37	Pusa Vikas x VRPK-07-01	5.29	2.93	49.62	46.45	101.98	5.65	18.05	3.05	17.65	16.12	2.09
38	Arka Suryamukhi x VRPK-07-01	6.19	8.11	66.14	62.19	23.10	2.59	8.92	4.16	17.16	13.45	3.16
39	Arka Chandan x VRPK-07-01	4.65	3.46	52.65	47.36	82.37	4.98	16.54	3.24	18.45	15.78	2.65
40	Azad Pumpkin x VRPK-07-01	5.00	4.72	61.24	55.62	54.25	4.26	12.37	2.52	18.83	16.35	3.14
Mean		6.00	4.69	57.84	51.97	73.35	4.68	15.45	3.97	17.31	15.35	3.17
Maximum		8.95	8.31	73.25	67.25	149.14	7.95	22.15	7.65	21.16	18.95	4.69
Minimum		3.65	2.93	46.15	45.35	23.10	2.59	8.90	2.15	13.85	11.65	2.09
SEm		0.20	0.16	1.89	1.79	2.45	0.22	0.60	0.19	0.79	0.66	0.14
C.D. at 5%		0.56	0.44	5.31	5.03	6.90	0.61	1.69	0.55	2.23	1.87	0.39
C.V. (%)		5.72	5.74	5.65	5.96	5.78	7.98	6.74	8.49	7.91	7.47	7.61
General (All)												
Mean		6.22	4.75	59.19	53.04	67.35	4.96	13.88	3.63	17.31	15.13	3.10
Maximum		10.24	8.31	73.25	68.95	149.14	10.25	22.15	7.65	21.95	18.95	4.69
Minimum		3.65	2.93	46.15	39.52	17.25	2.59	3.00	1.26	8.35	8.95	1.95
SEm		0.20	0.14	1.98	1.71	2.37	0.21	0.54	0.17	0.74	0.60	0.12
C.D. at 5%		0.55	0.40	5.55	4.80	6.65	0.58	1.52	0.49	2.08	1.68	0.35
C.V. (%)		5.49	5.21	5.80	5.60	6.11	7.20	6.75	8.32	7.43	6.88	6.91

VL = Vine Length (m), PB = Primary branches, FFFI = First female flower initiation, FMFI = First male flower initiation, MFPV = Male flower per vine, FFPV = Female flower per vine, SR = Sex ratio, FW = Fruit weight (Kg), FL = Fruit length (cm), FD = Fruit diameter (cm), FFT = Fruit flesh thickness (cm)

Sl. No.	Crosses & Parents	FFS	FPP	NSPF	HSW	FYPP	FFH	TSS	Yield (t/ha)
1	Pusa Vikas x Kashi Harit	62.24	3.06	192.87	10.14	9.67	85.66	8.46	15.37
2	Arka Suryamukhi x Kashi Harit	66.25	2.89	343.00	15.26	9.88	88.35	9.15	17.66
3	Arka Chandan x Kashi Harit	57.89	4.39	205.78	9.20	15.15	92.35	10.54	21.56
4	Azad Pumpkin x Kashi Harit	62.15	2.41	406.17	17.25	10.10	86.34	10.24	17.73
5	Pusa Vikas x Pumpkin 21-81	66.85	3.40	219.72	11.25	10.03	86.35	8.32	17.52
6	Arka Suryamukhi x Pumpkin 21-81	61.25	2.18	276.00	14.15	10.38	83.14	9.67	17.98
7	Arka Chandan x Pumpkin 21-81	57.49	3.45	238.17	7.98	10.18	90.15	11.95	16.63
8	Azad Pumpkin x Pumpkin 21-81	68.15	3.12	389.66	14.38	11.60	90.45	9.15	15.83
9	Pusa Vikas x VRPK-310	61.24	7.25	209.44	14.45	35.89	89.35	10.57	52.08
10	Arka Suryamukhi x VRPK-310	65.15	4.15	316.00	14.29	18.01	89.35	8.47	24.82
11	Arka Chandan x VRPK-310	61.29	4.37	222.60	9.56	16.04	89.95	9.47	23.61
12	Azad Pumpkin x VRPK-310	61.29	5.18	385.26	13.17	23.93	83.25	9.65	40.16
13	Pusa Vikas x Narendra Agrim	69.14	4.40	198.25	10.15	17.38	90.35	9.14	28.17
14	Arka Suryamukhi x Narendra Agrim	59.25	4.68	366.00	15.33	26.72	81.25	10.98	41.83
15	Arka Chandan x Narendra Agrim	63.78	4.66	207.55	8.79	17.06	85.45	8.65	24.75
16	Azad Pumpkin x Narendra Agrim	66.98	2.18	294.76	17.08	6.89	112.65	9.14	11.32
17	Pusa Vikas x Pumpkin-303	98.45	5.37	214.95	11.24	22.82	101.35	9.75	37.93
18	Arka Suryamukhi x Pumpkin-303	69.15	2.46	312.00	14.25	12.32	92.38	10.24	18.90
19	Arka Chandan x Pumpkin-303	61.25	4.28	258.36	8.19	15.75	83.25	10.27	26.33
20	Azad Pumpkin x Pumpkin-303	57.95	3.81	401.76	13.35	14.45	89.69	8.19	23.71
21	Pusa Vikas x Pumpkin-87	59.14	4.74	183.50	7.50	17.73	83.25	8.62	29.17
22	Arka Suryamukhi x Pumpkin-87	72.14	3.89	405.00	16.49	16.22	96.34	9.47	31.70
23	Arka Chandan x Pumpkin-87	65.25	4.51	156.25	7.39	18.58	85.35	10.88	30.58
24	Azad Pumpkin x Pumpkin-87	69.25	5.16	267.65	11.53	24.97	96.25	9.65	43.41
25	Pusa Vikas x Pumpkin-73	65.15	3.53	287.54	9.95	14.54	84.28	8.84	21.15
26	Arka Suryamukhi x Pumpkin-73	60.25	5.12	307.00	14.06	28.77	82.36	8.93	52.93
27	Arka Chandan x Pumpkin-73	54.69	4.36	207.24	7.24	20.27	85.25	9.67	34.89
28	Azad Pumpkin x Pumpkin-73	60.25	3.51	314.68	14.85	13.20	83.45	10.24	18.47
29	Pusa Vikas x Pumpkin V-4	62.14	6.05	185.35	8.24	18.88	91.00	9.64	32.57
30	Arka Suryamukhi x Pumpkin V-4	75.14	3.17	316.00	14.29	9.38	98.65	10.18	15.99
31	Arka Chandan x Pumpkin V-4	67.68	5.87	212.65	7.04	24.28	108.35	8.47	39.52
32	Azad Pumpkin x Pumpkin V-4	62.16	4.14	351.28	15.96	15.94	86.35	9.75	31.01
33	Pusa Vikas x Pumpkin LM-350	57.35	5.98	192.48	8.95	20.63	90.35	8.25	35.54
34	Arka Suryamukhi x Pumpkin LM-350	77.65	3.29	396.00	16.25	25.17	101.64	9.68	43.88
35	Arka Chandan x Pumpkin LM-350	57.49	4.98	204.85	6.95	10.71	89.65	8.45	17.99
36	Azad Pumpkin x Pumpkin LM-350	66.35	3.65	465.25	13.85	14.49	90.15	9.65	24.48
37	Pusa Vikas x VRPK-07-01	57.29	5.14	176.98	8.04	15.68	89.65	9.33	30.90
38	Arka Suryamukhi x VRPK-07-01	71.25	2.26	325.00	14.49	9.40	92.15	11.26	15.81
39	Arka Chandan x VRPK-07-01	56.78	4.26	196.24	7.24	13.80	85.24	9.68	23.43
40	Azad Pumpkin x VRPK-07-01	68.15	3.42	303.19	12.16	8.62	92.45	8.24	11.67

Mean	64.57	4.12	277.81	11.80	16.39	90.08	9.52	25.46
Maximum	98.45	7.25	465.25	17.25	35.89	112.65	11.95	52.93
Minimum	54.69	2.18	156.25	6.95	6.89	81.25	8.19	11.32
SEm	2.81	0.24	14.80	0.62	0.98	4.57	0.40	0.35
C.D. at 5%	7.90	0.67	41.66	1.76	2.75	12.88	1.12	0.98
C.V. (%)	7.53	10.04	9.22	9.16	10.33	8.79	7.26	2.38
General (All)								
Mean	65.26	4.30	250.44	10.67	15.55	88.34	9.58	21.14
Maximum	98.45	8.25	465.25	17.25	35.89	112.65	11.95	35.94
Minimum	53.17	2.18	109.62	5.14	5.11	71.24	8.19	7.71
SEm	2.79	0.23	12.72	0.54	0.92	3.98	0.38	0.30
C.D. at 5%	7.81	0.66	35.64	1.52	2.57	11.14	1.05	0.87
C.V. (%)	7.39	9.44	8.80	8.78	10.21	7.80	6.78	2.46

FFS = First fruit set, FPP = Fruit per plant, NSPF = No. of seeds per fruit, HSW = 100 seed weight (g), FYPP = Fruit yield per plant (kg), FFH = First fruit harvest and TSS = TSS (brix).

Conclusion

The present investigation revealed substantial variability among the parental genotypes and F_1 hybrids for all the quantitative and yield-related traits studied, demonstrating the effectiveness of hybridization in generating superior genotypes in pumpkin. The significant differences observed among the evaluated genotypes indicated the presence of sufficient genetic diversity, which can be effectively exploited for the development of high-yielding pumpkin cultivars.

Among the parental genotypes, Pumpkin-87, Pumpkin V-4, Pumpkin-73, Pumpkin-303, VRPK-310 and Arka Suryamukhi exhibited superior *Per se* performance for important yield and yield-contributing traits, including fruit weight, fruit yield per plant, total yield, fruit dimensions and fruit quality attributes. These parents may therefore serve as valuable genetic resources for future hybridization and varietal improvement programmes.

Evaluation of the F_1 hybrids identified several outstanding cross combinations with remarkable yield potential. Hybrids such as Arka Suryamukhi $\times$ Pumpkin-73, Pusa Vikas $\times$ VRPK-310, Arka Suryamukhi $\times$ Pumpkin LM-350, Azad Pumpkin $\times$ Pumpkin-87 and Arka Suryamukhi $\times$ Narendra Agrim exhibited superior performance for fruit yield and associated quantitative traits, indicating their potential for multilocation evaluation and commercial cultivation. The superior performance of these hybrids reflected the successful combination of desirable parental characteristics and highlighted the importance of selecting genetically diverse parents in pumpkin breeding.

Overall, the study demonstrated that *per se* performance evaluation is an effective approach for identifying superior parental lines and promising hybrids. The elite parents and high-performing hybrids identified in the present investigation can be effectively utilized in future breeding programmes aimed at developing high-yielding, superior-quality pumpkin cultivars suitable for diverse agro-climatic conditions.

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