



Genetic Variability, Heritability and Genetic Advance Analysis in Advance Wheat (*Triticum aestivum* L.) Breeding Lines

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Wheat (*Triticum aestivum* L.) holds significant importance as one of the leading cereal crops in the world, serving as a primary source of food. The genetic improvement of any breeding population largely depends on the amount of genetic variability present in a crop species. The current study

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was undertaken to obtain information of important genetic variability parameters in a set of fifty genotypes. The experiment was conducted at the farm of Wheat and Maize research Unit, Parbhani (Maharashtra) during *Rabi* season 2023-24. The genotypes were grown in randomized block design with two replications and data were collected on ten morphological traits. Analysis of variance showed significant differences among the genotypes for all the characters studied, indicating availability of wide range of variability among the genotypes. The estimation of genotypic coefficient of variance were found to be high for number of grains per spike, number of productive tillers/plant, grain yield/plant, 1000 grain weight. Heritability estimates were highest for number of grains per spike followed by days to 50% heading, grain yield/plant and spike length. The estimates of genetic advance as % of mean were highest for number of grains/spike, number of productive tillers/plant, grain yield/plant, and harvest index. High heritability coupled with high genetic advance as per cent mean was observed for number of productive tillers per plant, number of grains per spike, grain yield per plant which suggested that selection for these characters would be more effective for desired genetic improvement.

Keywords: Bread wheat; genetic variability; GCV; heritability; genetic advance.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is one the most important cereal crop grown worldwide. it is a member of the Gramineae family (sub-family Poaceae) and demonstrates remarkable adaptability, flourishing in various soil types and climatic conditions. Unlike rice, wheat is grown on every continent. Among major cereal crops, it is particularly resilient to both cold and drought conditions. Wheat Serves as a primary food source for a vast proportion of the global population, often known as the "king of cereals." As a key food source, it significantly contributes to fulfilling the nutritional requirements of a large share of the world's population. People use wheat in the form of flour to create various foods, including chapatis, pasta, bread, biscuits, cookies, noodles, dalia, maida, vermicelli, and more. Additionally, wheat straw serves as fodder for livestock and as packaging materials. Nutritionally, wheat is a valuable cereal, comprising mainly carbohydrates (65-70%) and proteins (11-12%). Gluten, the primary protein, makes up 75-85% of the total protein found in bread wheat. A 100-gram serving of wheat offers 327 kilocalories of energy along with a variety of essential nutrients, including proteins, dietary fibers, manganese, phosphorus, and niacin. It also contains a significant amount of vitamin b-complex. Wheat (*Triticum aestivum* L.) Is of special significance in Indian agriculture for triggering green revolution and during the coming decades it is expected to play a more important role in stabilizing national food production. Wheat (*Triticum spp.*) Is the second most important winter cereal in India after rice. "The share of wheat in total food grain production is around 36.25% and share in area is about 24.83 % of

the total area under food grains globally, wheat is cultivated on an area of 224.05 million hectares with a production of 793.37 mt. In India, wheat covers an area of 31.82 million hectares with a production and productivity of 112.74 million tonnes and 35.43 quintal per ha, respectively" (anonymous, 2023). In Maharashtra area under wheat cultivation was 1046000 ha, production of 1988000 tonnes and productivity was 1899 kg/ha in the year 2023-24.

The primary aim of wheat breeding is to develop high-yielding genotypes adaptable to diverse agro-climatic conditions and stress environments. Effective breeding programs depend on the availability of genetic variability within the crop population. Thus, genetic diversity in the gene pool is essential for initiating selection strategies. Mishra et al. (2019) reported higher PCV than GCV for grain yield per plant and plant height, indicating a substantial environmental influence on these traits. "Heritability serves as a reliable indicator of the extent to which traits are passed from parents to offspring" (Falconer, 1960). "Genetic advance refers to the difference between the average genotypic value of selected lines and that of the original parental population before selection. Both heritability and genetic advance are key selection parameters for improving specific traits or yield. Studying genetic advance is essential as it quantifies the genetic gain achieved through selection for a particular trait. A combination of high genetic advance and high heritability provides the ideal conditions for effective selection" (Johnson et al., 1955). Therefore, in any crop improvement program based on selection, analyzing genetic variability, heritability, and genetic advance together proves

to be highly beneficial. Hence, the present investigation was carried out to estimate the genetic variability, heritability and genetic advance which can be further used in breeding and crop improvement programme.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Design

The present investigation was carried out at Wheat and Maize research Unit, Parbhani (Maharashtra) during *Rabi* season 2023-24 under normal irrigated condition. The material used in the study comprised of fifty bread wheat genotypes received from Wheat and Maize research Unit, Parbhani. The genotypes sown in a randomized block design with two replications having plot size 4.0 X 0.20 m² and plant spacing of 20cm and 10cm respectively. All the recommended practices were followed to grow a healthy crop.

2.2 Characters Studied

The data were recorded from five randomly selected plants from each genotype on ten distinct morphological characters viz., days to 50% heading, days to maturity, plant height (cm), number of effective tillers/plants, spike length (cm), number of grains/spike, 1000-grains weight (g), grain yield/plant (g), biological yield/plant (g) and harvest index (%). Days to 50% heading and days to maturity observations were recorded on plot basis only once.

2.3 Statistical Analysis

The overall mean values of different characters were subjected to statistical analysis. Analysis of variance was done by subjecting the data to the statistical method on randomized block design (RBD) as described by Panse and Sukhatme (1985). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was computed according to the method suggested by Burton and de Vane (1953). The expected genetic advance (GA) expressed in percentage of mean were calculated by using the method suggested by Johnson et al. (1955).

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

An analysis of variance for ten characteristics was conducted, and the sums of squares are summarized in (Table 1). In this study, significant genotypic differences were identified for all ten traits. Significant differences among the genotypes for different traits. The presence of variability suggests that there is considerable opportunity to select superior genotypes that can either be used directly as a new variety or as parent sources in upcoming breeding programs. This study indicated that the variability observed in these fifty genotypes is due to the presence of diverse genotypes with different genetic backgrounds, as well as environmental influences. Similar results were also earlier reported by Kumar et al. (2016), Prasad et al. (2020) and Rahman et al. (2016) in wheat crop.

Table 1. Analysis of variance for yield and yield contributing characters in fifty genotypes of wheat

S. No	Characters	Mean sum of squares		
		Replications (df=1)	Treatments (df=49)	Error (49)
1	Days to 50% heading	5.290	25.740**	2.657
2	Days to maturity	1.210	29.357**	6.679
3	Plant height	28.048	37.601**	13.130
4	Number of tillers per plant	0.003	0.920**	0.179
5	Spike length	0.274	0.802**	0.112
6	Number of grains per spike	4.335	25.346**	1.753
7	1000 seed weight	1.734	36.918**	8.081
8	Biological yield per plant	0.006	6.653**	1.669
9	Grain yield per plant	0.304	2.297**	0.310
10	Harvest index	9.183	28.848**	13.173

*, ** Significant at $P = 0.05$ and $P = 0.01$ levels of probability, respectively

3.2 Mean Performance

The average performance of 50 genotypes along with mean, CV (%) and CD (5%) are presented in (Table 2). Based on mean performance, genotype PBN 345 (10.65 g), PBN 385 (10.50 g), PBN 351 (10.28 g), PBN 353 (10.26 g) and PBN 359 (10.25 g) exhibited higher grain yield per plant. While minimum grain yield/plant was noticed in genotype PBN 382 (6.50 g) followed by PBN 388 (6.62 g) and PBN 368 (6.62 g). It was observed that the mean value ranged from 6.50 g to 10.65 g with general mean of 8.47 g. Therefore, high variability for ten traits of fifty bread wheat genotypes indicated that there was reasonably sufficient variability to allow plant breeders to pick superior and desired genotypes for further improvement. In general, all of the traits studied had a wide range of variation. Similar results for variability of all characters were found in Singh et al. (2024), Yadav et al. (2020) and Ali et al. (2024).

3.3 Genotypic and Phenotypic coefficient of Variation

The estimates of mean, range, genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for ten characters studied are presented in (Table 3). In plant breeding programme, direct selection for yield as could be misleading. A successful selection depends upon the information on the genetic variability and association of morpho-agronomic

traits with grain yield. The PCV values were higher than GCV values for all the characters. However, differences among them were small indicating that the influence of environment on the expression of traits was low. Similar results on GCV and PCV for different characters were reported by Arya et al. (2017), Meles et al. (2017). Fikre et al. (2015) Bhushan et al. (2013) and Abinasa et al. (2011). High PCV and GCV values were observed for number of grains/spike (17.20) and (15.88), number of productive tillers/plant(13.84) and (12.26), grain yield/plant (13.47) and (11.76) and harvest index (11.97) and (7.31) indicating better opportunity for improvement in these traits through selection. However, moderate PCV and GCV was observed for 1000 grain weight (10.31) and (8.26), biological yield per plant (9.19) and (7.11), spike length (8.05) and 6.99). The lowest estimates of PCV and GCV were observed for days to maturity (3.93) and (3.11) respectively followed by plant height and days to 50% heading. The magnitude of PCV ranged from 3.93 for days to maturity to 17.02 for number of grains/spike while GCV ranged from 3.11 for days to maturity to 15.88 for number of grains/spike. The characters with high phenotypic coefficient of variation indicated more influence of environmental factors. Also the results observed above for variability were in accordance with Naik et al. (2015), Chauhan et al. (2023), Bishwas et al. (2023) Reddy et al. (2020) and Hayder et al. (2020).

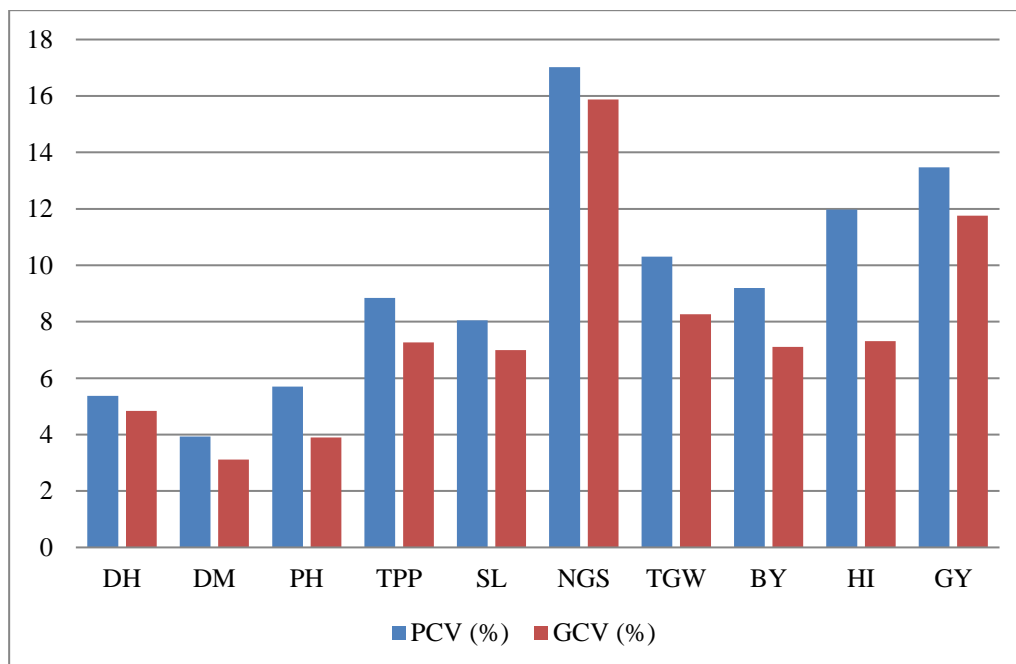


Fig. 1. Genotypic and Phenotypic coefficient of variation for ten characters in wheat

Table 2. Mean values of 50 genotypes for different yield attributing characters in wheat under field conditions

S. No	Genotypes	Days to 50% heading	Days to maturity	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Number of grains per spike	1000 seed weight(g)	Biological yield per plant(g)	Harvest index (%)	Grain yield per plant(g)
1	PBN 344	71.00	108.50	89.50	7.70	8.60	17.55	36.60	20.86	34.94	7.28
2	PBN 345	65.00	105.00	96.80	9.35	9.95	28.06	50.25	27.33	39.08	10.65
3	PBN 346	69.00	110.00	84.35	8.40	7.85	21.00	44.14	21.08	45.02	9.49
4	PBN 347	66.00	106.00	91.90	8.60	8.25	22.79	41.62	20.72	43.45	9.00
5	PBN 348	74.50	114.50	92.50	8.20	8.25	19.15	44.95	21.73	37.22	8.05
6	PBN 349	68.00	103.50	85.40	9.35	10.10	30.47	54.29	26.98	37.13	10.00
7	PBN 350	65.00	108.00	91.08	7.58	8.45	21.16	40.68	21.39	37.76	8.08
8	PBN 351	69.00	106.50	89.80	9.28	8.30	24.50	46.43	22.63	45.58	10.28
9	PBN 352	69.50	108.00	90.62	8.20	8.70	20.43	41.71	22.87	38.46	8.78
10	PBN 353	72.50	105.50	84.19	9.35	9.50	29.60	47.24	23.80	43.13	10.26
11	PBN 354	66.00	108.00	84.95	8.10	8.50	19.71	43.76	21.38	39.64	8.48
12	PBN 355	74.50	112.50	83.76	7.38	8.75	18.93	42.63	22.48	33.45	7.53
13	PBN 356	66.00	104.50	84.15	7.78	8.30	18.91	49.77	22.11	38.80	8.59
14	PBN 357	68.50	107.50	86.95	8.98	9.25	25.02	54.12	25.29	37.97	9.59
15	PBN 358	71.50	104.00	85.73	7.48	8.45	22.95	44.06	21.78	34.65	7.55
16	PBN 359	72.50	106.00	94.38	9.35	8.20	26.92	47.56	22.34	45.89	10.25
17	PBN 360	73.50	113.00	92.55	9.28	8.10	20.11	43.86	21.45	41.66	8.94
18	PBN 361	69.50	109.50	81.17	8.00	8.40	22.08	47.91	21.50	40.19	8.64
19	PBN 362	75.00	115.50	89.00	9.28	8.55	20.95	48.20	21.16	42.58	8.99
20	PBN 363	69.00	108.50	91.71	8.78	8.50	21.88	51.71	24.45	34.30	8.38
21	PBN 364	74.50	115.50	87.57	8.80	8.35	21.44	46.16	21.27	37.42	7.96
22	PBN 365	72.00	108.50	83.30	7.65	7.45	16.33	43.39	19.48	35.15	6.75
23	PBN 366	67.50	105.50	85.75	7.90	8.45	20.69	42.51	22.05	33.73	7.45
24	PBN 367	68.00	106.50	92.70	8.90	7.60	20.10	44.06	21.52	37.32	8.03
25	PBN 368	70.00	109.00	92.17	8.18	7.05	15.22	47.43	19.35	34.60	6.62
26	PBN 369	73.00	105.50	83.85	9.10	7.95	19.52	47.75	21.53	35.41	7.63
27	PBN 370	72.50	110.50	87.63	9.00	7.90	20.45	44.29	22.57	36.42	8.21
28	PBN 371	70.50	105.50	86.40	8.30	7.90	22.56	34.30	22.66	33.78	7.66
29	PBN 372	71.50	109.00	92.95	7.90	8.00	21.89	49.57	22.51	38.32	8.62
30	PBN 373	66.50	106.50	88.03	8.90	8.05	20.84	44.27	22.80	34.68	7.90
31	PBN 374	64.00	105.50	85.41	9.35	9.50	28.28	52.75	24.46	41.62	10.18
32	PBN 375	70.00	106.00	92.40	7.85	8.29	22.13	46.76	22.64	35.53	8.05
33	PBN 376	66.50	104.50	82.88	8.25	8.05	23.80	44.73	22.98	37.10	8.53
34	PBN 377	66.50	111.50	82.80	7.38	7.45	15.75	49.59	17.97	40.94	7.22
35	PBN 378	68.00	102.00	83.36	8.40	8.25	19.90	45.94	23.55	33.53	7.87
36	PBN 379	69.00	108.50	92.60	8.50	8.20	20.10	45.01	22.54	35.01	7.88
37	PBN 380	74.50	106.00	77.86	8.10	8.30	21.10	43.18	22.33	35.67	7.96
38	PBN 381	60.00	104.50	84.20	8.70	8.30	20.29	42.78	21.83	38.63	8.42
39	PBN 382	74.50	116.00	87.05	7.35	7.23	17.20	46.11	18.05	36.60	6.50

S. No	Genotypes	Days to 50 % heading	Days to maturity	Plant height (cm)	Number of tillers per plant	Spike length (cm)	Number of grains per spike	1000 seed weight(g)	Biological yield per plant(g)	Harvest index (%)	Grain yield per plant(g)
40	PBN 383	74.50	111.00	91.75	8.40	8.25	19.46	45.75	20.57	44.48	9.14
41	PBN 384	68.00	101.50	89.74	7.98	8.45	20.85	43.18	22.06	33.98	7.42
42	PBN 385	75.00	101.00	80.00	9.28	9.50	20.00	48.75	21.94	47.84	10.50
43	PBN 386	74.00	105.50	86.75	9.35	8.95	29.08	53.75	24.94	40.98	10.23
44	PBN 387	67.00	108.00	84.80	7.93	8.05	20.52	40.62	21.58	35.77	7.73
45	PBN 388	70.50	108.50	86.95	7.78	7.60	16.55	47.54	19.92	33.14	6.60
46	PBN 389	69.00	106.00	85.30	7.98	8.25	21.18	42.47	22.85	36.54	8.35
47	PBN 390	74.00	115.50	95.03	7.68	8.65	19.50	53.82	22.23	39.60	8.81
48	PBN 391	73.50	112.00	85.60	7.35	8.50	21.90	41.23	21.60	39.99	8.60
49	PBN 392	77.50	115.50	93.55	7.35	8.65	23.33	46.71	21.25	43.77	9.27
50	PBN 393	70.00	104.00	94.55	9.28	9.45	28.85	52.46	25.03	35.08	8.78
Range lowest		60	101	77.86	7.35	7.05	15.22	34.3	17.97	33.14	6.5
Range highest		77.5	116	96.8	9.35	10.1	30.47	54.29	27.33	47.84	10.65
Mean		70.15	107.99	87.86	8.38	8.39	21.61	45.96	22.18	38.27	8.47
C.V.(%)		2.32	2.39	4.12	5.04	3.99	6.12	6.18	5.82	9.48	6.57
C.D.(5%)		3.23	5.12	7.19	0.83	0.66	2.62	5.64	2.56	7.2	1.1

Table 3. Estimates of variability parameters for ten characters for yield and yield contributing characters in 50 genotypes of wheat

S. No	Characters	Mean	Range		PCV (%)	GCV (%)	Heritability(b.s) (H ²) (%)	Genetic Advance as % of mean
			Min	Max				
1	Days to 50 % heading	70.15	60	77.5	5.37	4.84	81.28	8.994
2	Days to maturity	107.99	101	116	3.93	3.11	62.93	5.09
3	Plant height (cm)	87.86	77.86	96.8	5.7	3.9	48.24	5.69
4	Number of productive tillers/plant	8.38	7.35	9.35	13.84	12.26	67.45	22.80
5	Spike length (cm)	8.39	7.05	10.10	8.05	6.99	75.45	12.52
6	Number of grains/spike	21.61	15.22	30.47	17.02	15.88	87.06	30.53
7	1000 grain weight (g)	45.96	34.30	54.29	10.31	8.26	64.08	13.62
8	Biological yield/plant (g)	22.18	17.97	27.33	9.19	7.11	59.93	11.35
9	Harvest index%	38.27	33.14	47.84	11.97	7.31	37.31	14.20
10	Grain yield/plant (g)	8.47	6.50	10.65	13.47	11.76	76.21	21.15

GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation

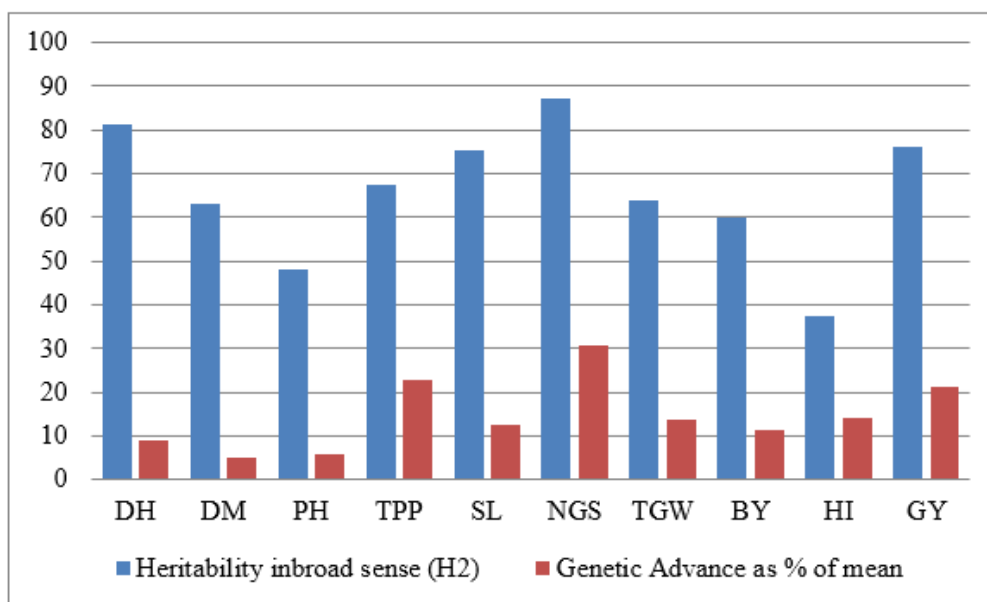


Fig. 2. Heritability and Genetic advance as per cent of mean for ten characters in wheat

3.4 Heritability and Genetic Advance as Percent of Mean

Heritability specifies the proportion of the genotypic variance to the total phenotypic variance. It is a good index for transmission of characters from parents to the offsprings. Genetic advance is the difference between mean genotypic value of selected lines and mean genotypic value of parental population (original population before selection). Heritability and genetic advance are important selection parameters for improvement of specific traits or yield. High genetic advancement coupled with high heritability estimates offer the most suitable condition for selection. Therefore, for any crop improvement programme through selection, the study of genetic variability and heritability together with genetic advance will be more useful.

The estimates of heritability and expected genetic advance for various characters studied are shown in (Table 3). Heritability estimates were highest for number of grains/spike (87.06), followed days to 50% heading (81.28), grain yield/plant (76.21), spike length (75.45). Lowest heritability shown by harvest index (37.21) followed by plant height (48.24).

Highest value of expected genetic advance expressed as percent of mean was observed for number of grains/spike (30.53), number of

productive tillers/plant (22.8) and grain yield/plant (21.15). High heritability coupled with high genetic advance (per cent of mean) was observed for grain number of productive tillers per plant, number of grains per spike, grain yield per plant which suggested that these characters can be considered as important for improvement through selection. 1000 grains weight, spike length and harvest index showed high heritability coupled with moderate genetic advance. Low genetic advance values were found for days to maturity and plant height indicating slow progress through selection for these characters. The results were in accordance with Arya et al. (2017), Meles et al. (2017), Fikre et al. (2015), Bishwas et al. (2023) and Sivakumar et al. (2023).

4. CONCLUSION

The results of the present study indicate that there was considerable genetic variability among the genotypes for most of the traits examined. Traits with moderate to high levels of variability and genetic advance should be prioritized for effective yield improvement. The presence of predominantly additive gene action, which is heritable and has high selection value, suggests that applying selection pressure on these traits would be beneficial. Such traits can be effectively improved through appropriate breeding methods. Selection is expected to be more successful when traits exhibit moderate to high heritability combined with moderate to high genetic

advance. Also, the phenotypic coefficient of variation (PCV) exceeded the genotypic coefficient of variation (GCV) for all traits indicates that influence of environmental factors on expression of traits. The small difference between PCV and GCV for certain traits further suggests strong genetic control, enhancing the potential for effective selection.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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