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Comprehensive study of selection parameters in wheat genotypes for grain yield

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Abstract
The current study, conducted during the rabi season of 2022 at the CRC, College of Agriculture, SVPUA&T, Meerut, aimed to evaluate the agronomic traits of 150 wheat genotypes obtained from the Division of Genetics and Plant Breeding, IARI, New Delhi. An augmented block design was utilized for the experiment, with a plot size of 2 x 1.5 m² and row-to-row and plant-to-plant spacing of 25 cm and 5 cm, respectively. The analysis of variance (ANOVA) revealed significant differences (p<0.01) across all traits, indicating the influence of environmental factors and treatment conditions on trait variability. Notably, traits such as days to booting (DTB), days to flowering (DTF), flag leaf area (FLA), and plant height (PH) displayed substantial genetic variation. Mean performance analysis identified genotype 4 as the top performer for leaf area, total grain weight, and plant weight, while genotype 45 exhibited early booting and flowering traits. Correlation analysis highlighted significant relationships among traits, with strong positive correlations among critical yield components, including DTB, DTF, and plant maturity. These findings underscore the importance of genetic selection and the intricate interplay of traits in wheat breeding programs aimed at enhancing yield and stress resilience. The study offers valuable insights for future breeding efforts to optimize wheat performance in varying environmental conditions.

Keywords: Wheat, ANOVA, correlation, breeding, yield

Introduction
Among food grains, bread wheat (Triticum aestivum L.) stands as one of the most significant cereal crops globally, ranking third in terms of area harvested and production after rice and maize. It serves as a staple food for 40% of the global population, supplying 20% of the world's dietary calories (Shiferaw *et al*., 2013) [4]. Wheat contributes essential nutrients to human diets, including proteins, vitamins, dietary fiber, and beneficial phytochemicals (Shewry and Hey, 2015) [5]. In 2019, wheat was cultivated on 215.9 million hectares, producing 765.8 million tonnes globally, accounting for 8% of the world's food basket (FAO Stat, 2021) [6]. By 2050, the demand for wheat is expected to rise by 60%, yet production may decrease by ~30% due to extreme climate conditions (CIMMYT, 2021) [7].
Wheat is grown across six diverse agro-ecological zones in India, covering 29.14 million hectares, producing 102.2 million tonnes with a record average productivity of 3507 kg/ha (Agri. Stat, 2019). It contributes 35% of total food production and 21% of the total cultivated area in the country (Tripathi and Mishra, 2017) [9]. Key wheat-growing states in India include Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, Rajasthan, Bihar, and Gujarat, with Uttar Pradesh, Punjab, Madhya Pradesh, and Haryana producing nearly 80% of the total wheat. India ranks first globally in wheat cultivation area and second in production, following China. Besides being a staple food, wheat also serves as a major fodder source for livestock and provides livelihood to millions of farmers worldwide. Global climate change has posed significant challenges to agricultural productivity, threatening food security worldwide. The growing human population, projected to reach 10 billion by 2050, necessitates major advancements in global food systems to ensure sustainable development and food security (FAO, 2017). Wheat production faces multiple challenges, including unpredictable temperature changes during the grain filling period (GFP), decreasing water availability for irrigation, soil salinity, and the emergence of new virulent strains of wheat rusts and leaf blight. Additionally, monocropping of rice-wheat systems year after year has impacted soil health and productivity.

Of these challenges, high-temperature stress during GFP is particularly critical, leading to reduced yield and grain quality. To meet global food security needs, wheat production must increase from an average of 2.6 to 3.5 tonnes per hectare over the next 25 years (Ortiz *et al*., 2008) [11]. Addressing these challenges will require systematic research efforts and the use of diverse germplasm through both conventional and modern breeding approaches to boost wheat production while maintaining quality standards.

Material and Methods

The current study was conducted during the rabi seasons of 2022 at the CRC, college of agriculture, SVPUA&T, Meerut. The 150 genotypes were obtained from the Division of Genetics and Plant Breeding, IARI, New Delhi. The experiment was set up in an augmented block design, with a plot size of 2 x 1.5 m^2 and row-to-row and plant-to-plant spacing of 25 and 5 cm, respectively.

Results

Analysis of variance

The results from the analysis of variance (ANOVA) (Table 1) revealed significant differences across various traits measured in the wheat genotypes. The "Block" effect was highly significant (p<0.01) for all traits, including days to booting (DTB), days to flowering (DTF), flag leaf area (FLA), plant maturity (PM), plant height (PH), spike length (SL), number of spikelets per spike (NSS), number of grains per spike (NGS), thousand grain weight (TGW), and harvest index (HI). This suggests that environmental factors across the blocks contributed to variability in these traits.

Mean performance

The analysis of mean performance across various genotypes reveals key insights into their agricultural traits (Table 2). The mean days to booting (DTB) was recorded at 79.08, with genotype 45 demonstrating the earliest booting at 104.50 days. For days to flowering (DTF), the mean was 93.02 days, while genotype 11 led with a remarkable 119.00 days. In terms of leaf area (FLA), the average was 38.52 mm^2, and genotype 4 exhibited the highest leaf area of 54.00 mm^2. The mean performance for plant maturity (PM) stood at 126.38, with genotype 45 again outperforming others at 145.00. The average plant height (PH) across genotypes was 115.15 cm, with genotype 48 reaching a significant 152.00 cm. Notably, the average seed length (SL) was 11.79 mm, with genotype 4 having the largest seeds at 13.30 mm. In terms of number of seeds per spike (NSS), the mean was 20.24, and genotype 4 recorded the highest at 22.40 seeds. Genotype 30 showcased the highest number of grains per spike (NGS) at 67.90, while the average total grain weight (TGW) was 45.40 g, with genotype 4 again leading with 60.00 g. Harvest index (HI) averaged 39.41%, and genotype 25 excelled with an HI of 39.30%. For spike area (SA), the mean was 37.71 mm^2, with genotype 11 exhibiting the largest spike area at 59.80 mm^2. The mean for spike length (SL) was 6.45 mm, with genotype 5 showing the longest spikes at 7.41 mm. The average spike breadth (SB) was 3.06 mm, and genotype 6 exhibited the broadest at 3.14 mm. The mean for spike peduncle (SP) was 16.55 mm, with genotype 12 showing the longest peduncle at 16.78 mm. The mean for stem area (SAL) was 4.75 mm, with genotype 42 achieving the highest area at 10.00 mm. In terms of culm circumference (CC), the mean was 47.81 mm, while genotype 4 had the largest circumference at 77.50 mm. The mean for moisture stress index (MSI) was 5.33%, with genotype 12 demonstrating the most resilience at 10.00%. Average plant weight (PW) was 48.36 g, with genotype 4 having the heaviest weight at 77.50 g, and the mean yield per plant (YPP) was recorded at 861.37 g, with genotype 30 achieving the highest yield of 1109.30 g. Overall, genotype 4 stood out as the best for leaf area, total grain weight, and plant weight, while genotype 45 showed early booting and flowering traits, making both genotypes essential for selection in breeding programs.

Table 1: Analysis of variance for 19 morpho-physiological and yield related traits in wheat

Source of variation	DF	DTB	DTF	FLA (mm2)	PM	PH (cm)	SL	NSS	NGS	TGW	HI (%)
Block	4	2094.10	1118.73	78.34	1357.58	259.70	22.21	9.82	353.70	478.38	33.18
TREAT	149	100.97	77.49	62.26	64.14	233.51	1.65	1.84	60.01	43.81	24.84
CHECKS	4	102.74	110.32	160.71	42.44	34.43	1.49	3.03	70.87	11.04	17.07
T.ENTRY	144	149.50	99.24	62.05	93.61	231.33	2.26	2.06	69.26	52.37	22.09
cHKvTEST	1	6893.74	3186.10	301.17	-4093.26	1344.24	-85.80	-35.23	-1315.00	-1058.55	451.56
ERROR	16	4.15	7.10	1.31	13.23	9.02	0.11	0.32	2.09	1.53	1.58
TOTAL	169	138.98	95.47	56.87	89.93	212.88	1.99	1.88	61.48	50.09	22.84

Source of variation	DF	SA (mm2)	SL (mm)	SB (mm)	SP (mm)	SAL	CC	MSI (%)	PW	YPP (g)
Block	4	7.18	0.74	0.096	4.33	0.27	64.15	26.57	3.44	28174.49
TREAT	149	3.33	0.17	0.034	0.83	0.15	16.26	55.13	3.61	29108.60
CHECKS	4	13.27	0.84	0.068	3.61	1.46	70.25	141.72	6.82	33927.66
T.ENTRY	144	3.26	0.17	0.035	0.86	0.12	16.22	53.34	3.61	27593.65
cHKvTEST	1	-26.65	-2.42	-0.256	-14.34	-0.88	-193.74	-34.01	-8.85	227984.85
ERROR	16	0.22	0.03	0.007	0.19	0.02	1.70	3.59	0.03	725.29
TOTAL	169	3.12	0.17	0.033	0.85	0.14	16.01	49.57	3.27	26399.31

Table 2: Mean performance and range for 19 morpho-physiological and yield related traits in wheat

	Genotype	DTB	DTF	FLA (mm2)	PM	PH (cm)	SL	NSS	NGS	TGW	HI (%)	SA (mm2)	SL (mm)	SB (mm)	SP (mm)	SAL	CC	MSI (%)	PW	YPP (g)
1	1	77.00	90.50	33.70	122.50	134.00	11.50	20.70	34.80	33.80	37.00	13.80	6.24	2.91	15.27	4.57	42.19	76.20	4.00	868.80
2	2	78.60	90.50	38.10	127.00	104.90	12.90	19.50	41.30	46.40	40.50	15.20	6.50	2.99	15.95	5.02	49.21	66.50	7.00	897.80
3	3	78.00	91.50	37.30	127.00	138.50	10.50	19.40	41.10	39.20	33.50	17.72	7.05	3.22	17.43	5.58	46.54	72.30	4.00	831.80
4	4	84.00	98.50	54.00	133.00	133.90	13.30	22.40	60.00	38.00	30.30	15.65	6.77	3.16	16.78	5.13	48.49	77.50	5.00	1203.80
5	5	71.00	87.50	35.20	124.00	89.40	10.40	18.90	41.10	46.60	39.40	17.93	7.41	3.14	17.79	5.24	38.64	57.70	6.50	724.80
6	6	72.00	90.00	39.30	124.50	89.20	11.60	21.90	59.00	36.90	38.90	14.66	6.67	2.95	16.23	4.76	41.73	63.20	5.50	795.80
7	7	72.00	88.50	33.50	124.00	88.70	10.70	18.20	36.20	49.10	43.20	16.08	6.16	3.09	15.48	4.77	35.88	70.70	6.50	813.80
8	8	75.00	91.50	36.10	127.00	128.50	10.20	18.20	39.40	46.60	37.80	16.74	6.75	3.23	16.75	5.53	45.25	63.20	4.50	817.80
9	9	72.50	92.00	38.60	127.00	126.00	11.10	18.90	44.90	44.70	33.20	17.34	7.06	3.12	17.31	5.11	51.40	58.60	4.50	752.80
10	10	82.00	96.00	41.90	127.00	100.20	13.20	20.70	39.80	49.00	42.60	16.28	6.60	3.11	16.43	4.94	46.77	72.70	6.00	694.10
11	11	93.00	119.00	59.80	143.00	109.40	15.60	21.20	29.70	30.00	21.60	16.65	6.64	3.13	16.47	4.68	42.55	75.80	7.00	450.10
12	12	74.00	95.00	45.00	127.50	123.50	12.80	20.20	40.60	46.90	35.30	14.56	6.53	2.83	15.79	4.94	40.62	69.00	6.50	732.10
13	13	79.00	98.50	33.20	129.00	103.50	11.10	20.90	58.90	37.00	45.30	15.71	5.91	3.18	15.08	4.72	42.45	66.70	8.00	784.10
14	14	81.00	99.00	39.80	127.50	111.90	12.60	22.00	64.10	34.90	37.90	12.20	6.00	2.59	14.70	4.68	43.88	69.80	7.00	819.00
15	15	73.00	90.00	35.80	126.00	127.40	11.00	19.50	35.00	42.90	31.40	17.49	6.54	3.40	16.65	4.87	47.70	71.30	2.00	619.10
16	16	72.00	87.50	33.40	124.50	98.90	11.90	18.00	44.60	38.50	42.00	13.22	6.03	2.59	14.71	4.70	47.32	70.00	6.50	762.10
17	17	82.00	99.50	44.60	133.00	101.70	12.30	21.20	47.20	35.60	37.30	16.16	6.38	3.23	16.00	4.88	43.03	63.00	5.50	776.10
18	18	79.00	97.00	37.90	127.50	123.20	12.20	21.70	51.20	41.40	36.20	16.33	6.54	3.12	16.15	5.15	45.68	76.20	10.00	812.10
19	19	82.00	99.00	27.30	129.00	98.90	11.90	17.70	44.20	42.00	36.30	16.00	6.68	3.20	16.40	4.65	45.28	76.00	1.00	752.10
20	20	74.00	92.00	35.90	125.00	108.50	11.50	21.40	64.50	35.00	39.00	15.78	6.06	3.16	15.38	4.75	46.68	52.80	8.50	973.30
21	21	72.00	93.00	29.80	125.00	106.50	10.40	20.20	49.90	43.20	42.70	16.73	6.90	3.00	16.83	5.23	44.47	53.60	6.50	850.30
22	22	73.00	87.50	34.60	123.50	103.90	11.10	18.20	45.70	41.30	39.20	16.89	7.06	3.22	17.18	5.30	50.40	53.50	6.00	865.30
23	23	75.00	93.50	35.20	125.50	104.50	11.80	21.00	58.10	31.80	41.00	16.11	6.16	3.03	15.45	4.45	36.21	55.50	4.50	786.30
24	24	74.30	93.00	42.00	127.50	106.00	11.00	18.70	46.30	34.90	30.50	17.84	6.50	3.25	16.53	5.19	45.79	58.50	7.00	673.30
25	25	85.00	102.00	40.80	130.00	117.50	13.50	22.40	64.10	39.30	36.10	15.43	6.41	3.00	15.91	4.50	45.99	56.50	10.00	907.30
26	26	81.50	93.50	35.10	126.00	111.40	12.30	20.50	50.50	39.70	38.20	15.61	6.78	3.12	16.82	4.93	42.59	55.70	4.00	783.30
27	27	82.00	95.00	42.10	126.50	113.40	12.40	21.40	47.00	39.30	38.90	15.15	6.85	2.94	16.70	4.73	50.68	55.50	6.00	931.30
28	28	78.50	91.50	38.90	127.00	131.50	11.80	18.90	47.60	44.20	32.50	16.62	6.31	3.32	16.06	4.81	42.57	56.80	4.50	787.30
29	29	78.00	91.00	33.70	126.50	86.00	10.20	16.90	35.50	39.30	36.50	17.02	6.75	3.30	17.01	4.95	49.48	52.00	7.00	899.30
30	30	82.00	95.50	34.70	128.00	108.00	10.70	20.20	51.50	37.70	41.00	14.90	6.30	2.88	15.57	4.78	47.79	73.20	1.50	1109.30
31	31	84.00	93.00	37.00	128.00	102.90	13.00	21.90	67.90	40.20	45.90	12.82	5.69	2.80	14.20	4.62	43.60	72.60	7.50	989.30
32	32	81.00	94.50	36.80	128.00	105.90	11.20	22.00	68.01	40.50	39.90	17.16	6.41	3.17	15.99	5.02	46.48	69.80	3.00	901.30
33	33	72.50	85.50	31.60	123.00	97.50	10.30	19.40	46.80	40.30	41.70	16.99	6.58	3.13	16.35	4.97	46.15	64.70	8.00	856.30
34	34	71.00	84.50	27.90	121.00	100.90	9.80	20.00	44.90	41.40	44.60	18.65	7.08	3.32	17.52	5.67	47.31	71.10	6.50	808.30
35	35	73.50	85.00	36.40	122.50	101.20	11.70	19.50	48.80	39.60	41.40	16.95	6.59	3.20	16.28	4.79	47.77	67.70	7.00	941.30
36	36	77.50	90.00	39.00	123.00	106.70	11.20	18.70	48.90	41.80	41.60	18.33	6.94	3.33	17.30	4.96	47.90	66.30	6.00	938.30
37	37	81.00	93.00	44.50	126.50	101.40	12.90	21.50	66.70	38.30	39.70	17.31	6.70	3.26	16.54	5.20	44.17	71.60	6.50	902.30
38	38	79.00	91.00	40.00	125.00	100.90	11.50	20.00	45.90	39.00	34.30	15.05	6.32	3.11	15.90	4.93	44.58	65.20	9.00	662.30
39	39	73.00	86.50	38.90	123.00	107.40	13.70	22.00	57.60	46.60	43.30	16.99	6.71	3.08	16.60	5.05	45.97	70.10	7.50	908.30
40	40	74.50	89.00	33.30	126.50	87.50	11.50	19.50	41.10	39.80	47.30	18.39	6.59	3.01	16.39	4.58	45.93	76.40	7.50	778.30
41	41	75.00	91.50	25.60	125.50	88.40	11.10	20.70	56.40	35.90	45.70	18.42	7.34	3.28	17.98	5.38	49.18	74.80	7.00	813.30
42	42	73.00	91.00	41.60	125.50	102.70	12.90	20.70	56.80	40.80	40.20	14.22	6.38	3.10	15.91	4.58	44.41	71.70	7.50	863.30
43	43	75.00	86.00	34.90	124.00	98.20	12.80	20.40	46.00	47.80	45.50	18.08	6.83	3.22	16.99	5.13	46.72	73.90	1.50	793.30
44	44	76.50	91.50	26.90	127.50	108.00	11.80	18.90	44.00	37.70	37.40	16.53	6.50	3.24	16.27	4.99	49.02	63.10	7.00	946.30
45	45	104.50	113.00	43.74	142.50	124.50	10.44	18.40	55.80	33.25	37.98	15.19	6.63	2.93	16.27	4.93	43.73	57.20	2.00	930.50
46	46	105.00	113.00	46.08	145.00	128.40	9.77	19.90	56.10	28.80	36.58	16.60	6.58	3.08	16.40	5.00	42.43	66.70	6.50	610.50
47	47	101.50	110.00	32.97	144.00	134.55	8.97	18.50	55.20	33.65	32.02	17.05	6.72	3.27	16.73	5.08	48.83	50.00	5.50	610.50
48	48	116.00	122.50	24.91	152.00	115.55	7.95	18.80	59.70	19.15	42.78	16.39	6.70	3.13	16.63	5.12	46.40	58.90	10.00	585.50
49	49	105.00	109.00	41.07	144.50	122.15	8.58	20.60	55.20	30.40	37.93	13.38	6.72	2.79	16.11	4.72	52.24	56.50	1.00	719.50
50	50	105.50	114.50	31.87	145.50	139.15	10.30	18.60	56.70	23.25	28.00	16.12	6.56	3.38	16.73	5.28	51.74	55.70	8.50	643.50
51	51	90.50	105.50	47.89	144.00	108.65	8.79	19.20	55.50	39.65	39.19	13.84	6.69	3.05	16.42	5.20	46.40	55.50	6.50	520.50
52	52	103.50	113.00	33.72	145.00	143.75	10.71	19.60	49.50	30.75	32.17	14.50	6.73	3.19	16.55	5.17	49.94	56.80	6.00	175.50
53	53	108.00	114.50	35.04	148.50	133.30	8.72	16.40	59.40	24.55	41.85	15.32	6.78	3.04	16.63	4.67	46.87	52.00	4.50	533.50
54	54	101.00	112.50	44.83	147.00	130.80	8.49	18.00	61.20	33.50	34.19	18.55	7.35	3.34	18.00	5.83	40.63	73.20	7.00	626.50
55	55	97.50	113.00	45.01	148.00	124.40	9.39	19.20	55.50	29.40	31.12	16.15	6.56	3.14	16.28	4.78	50.05	72.60	5.00	498.50
56	56	95.00	113.50	29.50	146.50	96.25	9.53	18.90	55.50	34.75	35.28	14.63	6.22	3.08	15.69	4.46	45.47	69.80	6.50	330.50
57	57	99.50	112.00	33.78	145.50	126.55	10.79	18.60	66.30	34.30	38.92	13.24	6.24	2.91	15.27	4.57	46.84	64.70	2.50	735.50
58	58	87.50	103.50	29.11	142.50	98.65	11.04	21.50	57.90	35.30	27.60	14.64	6.50	2.99	15.95	5.02	49.82	71.10	5.50	590.50
59	59	112.00	116.50	33.63	150.50	136.80	10.26	20.30	53.70	17.30	36.48	17.16	7.05	3.22	17.43	5.58	48.75	67.70	8.00	588.50
60	60	106.00	114.50	40.63	146.50	125.15	10.22	17.70	53.70	30.55	35.62	15.09	6.77	3.16	16.78	5.13	56.60	66.30	7.00	630.50
61	61	96.50	108.00	34.05	142.50	126.90	9.60	19.10	54.30	36.90	36.88	17.84	7.07	3.26	17.52	5.13	46.05	71.60	7.00	732.50
62	62	103.50	107.50	28.56	147.50	137.50	8.48	18.40	55.20	20.55	40.57	15.47	6.77	2.89	16.40	5.11	41.30	65.20	7.00	692.50
63	63	99.50	113.50	38.72	148.50	109.40	8.78	18.70	50.10	29.15	40.71	15.69	6.55	3.18	16.38	4.90	54.05	70.10	6.00	810.50
64	64	92.50	106.50	35.99	140.50	99.30	9.00	19.30	60.90	34.00	39.00	15.03	6.36	3.07	16.00	4.83	45.89	76.40	6.00	735.50
65	65	103.00	109.50	37.34	147.50	104.90	9.28	19.70	54.90	26.65	39.95	17.90	7.24	3.35	17.82	5.44	51.63	74.80	8.00	705.50

66	66	105.50	115.00	44.36	147.00	101.05	9.81	18.10	56.40	32.25	41.68	16.51	6.83	3.18	16.83	4.85	49.99	57.20	8.00	790.50
67	67	98.50	109.50	32.00	142.50	85.25	8.54	18.00	60.30	31.80	37.71	16.36	7.00	3.32	17.34	5.64	52.24	66.70	6.00	725.50
68	68	99.00	113.00	36.17	147.50	140.40	10.07	19.20	60.90	31.25	39.51	18.79	7.35	3.50	18.29	5.72	48.05	50.00	8.00	730.50
69	69	103.00	112.50	44.38	147.00	116.15	10.51	19.50	61.80	35.75	40.92	16.50	6.54	2.98	16.09	4.35	53.70	58.90	2.00	720.50
70	70	87.00	103.50	38.83	138.00	101.80	10.06	19.10	61.50	38.90	34.27	16.90	6.78	3.08	16.58	4.96	44.04	56.50	4.00	1035.50
71	71	107.00	114.50	42.50	145.50	114.65	10.12	19.00	58.80	22.30	30.87	17.37	7.41	3.14	17.79	5.24	45.03	55.70	8.00	812.50
72	72	94.00	105.00	35.44	136.00	109.25	9.72	18.90	55.80	29.40	30.11	14.10	6.67	2.95	16.23	4.76	57.92	55.50	6.00	885.50
73	73	101.00	109.50	40.62	143.50	116.05	10.61	17.70	59.10	20.40	30.26	15.52	6.16	3.09	15.48	4.77	52.14	56.80	8.00	961.50
74	74	106.00	111.00	42.67	148.00	122.65	9.36	20.70	61.50	29.90	30.25	16.18	6.75	3.23	16.75	5.53	41.77	52.00	7.00	915.50
75	75	91.50	106.00	32.03	142.50	91.80	9.97	20.70	66.30	26.25	40.35	16.78	7.06	3.12	17.31	5.11	40.80	73.20	5.00	935.50
76	76	91.00	100.50	37.96	144.00	124.25	7.99	18.10	52.50	33.00	42.39	15.22	6.54	3.07	16.22	4.94	46.07	72.30	6.50	553.50
77	77	85.00	100.50	38.91	137.50	97.40	8.41	16.80	57.60	31.40	37.69	18.67	7.28	3.22	17.88	5.15	45.40	77.50	5.50	739.50
78	78	112.50	117.50	40.10	153.50	133.40	9.63	18.80	52.50	27.75	40.41	16.57	7.65	3.17	18.51	5.58	46.14	67.60	6.50	530.50
79	79	106.00	114.50	33.14	147.50	115.50	9.34	19.00	49.80	32.05	35.47	16.35	6.44	3.24	16.16	4.86	48.84	72.10	4.50	460.50
80	80	94.00	107.00	50.97	144.50	108.00	9.29	19.50	57.60	37.15	41.38	14.46	6.35	2.87	15.65	5.06	49.04	77.10	4.50	630.50
81	81	96.00	108.00	40.62	144.50	126.55	8.86	19.60	57.60	34.75	38.80	20.24	8.20	3.16	19.47	5.83	52.78	65.20	6.00	595.50
82	82	104.50	111.50	46.71	146.50	101.90	9.16	18.10	56.70	41.55	37.99	17.37	6.77	3.25	16.85	5.02	48.48	67.10	7.00	572.50
83	83	94.50	102.00	36.18	139.00	117.50	10.29	17.70	54.30	34.50	39.82	19.78	7.34	3.46	18.10	5.51	40.99	63.90	6.50	1000.50
84	84	105.50	110.00	41.31	148.00	114.30	8.86	19.00	48.60	34.55	37.92	15.37	6.25	3.00	15.53	4.88	45.24	77.10	8.00	999.50
85	85	104.50	110.50	47.94	148.50	107.05	10.53	20.00	53.40	26.90	44.59	15.14	6.45	2.91	15.80	4.80	42.53	71.80	7.00	872.50
86	86	86.50	101.00	45.03	138.50	105.05	8.65	19.00	57.00	38.40	34.23	18.20	6.89	3.30	17.30	5.16	50.30	67.30	7.50	893.50
87	87	96.00	108.00	45.81	144.50	146.55	9.16	18.70	56.40	32.25	37.68	19.96	6.90	3.48	17.46	4.68	52.78	60.60	7.50	990.50
88	88	95.00	107.50	45.38	143.50	128.90	9.16	18.70	55.20	36.30	37.64	15.23	6.15	2.95	15.39	4.85	51.18	57.70	6.50	399.50
89	89	97.00	109.00	38.10	144.00	123.90	9.25	19.30	54.60	32.15	31.44	12.17	6.09	2.61	14.88	4.85	46.97	63.20	4.50	855.50
90	90	105.50	116.00	34.57	147.50	111.65	8.89	19.50	53.70	25.05	39.58	18.29	6.93	3.08	16.97	5.56	53.20	70.70	4.50	708.50
91	91	104.00	114.00	45.03	150.50	149.05	9.33	20.40	55.20	33.65	34.55	16.28	6.10	3.01	15.26	4.68	50.87	63.20	7.50	598.50
92	92	105.00	114.00	30.93	145.00	126.90	10.61	20.30	56.40	31.80	36.30	12.35	5.73	2.99	14.55	4.37	54.27	58.60	7.50	592.50
93	93	105.00	113.50	40.74	146.00	123.40	10.28	20.70	61.20	28.90	36.11	14.39	5.93	3.27	15.29	4.28	52.41	72.70	6.00	855.50
94	94	93.00	106.50	39.67	139.50	133.40	9.44	18.80	58.50	32.00	36.80	15.83	6.73	2.88	16.37	5.15	46.71	75.80	8.50	510.50
95	95	95.00	111.00	51.44	147.50	130.80	9.06	19.80	57.60	29.75	37.27	15.58	6.22	2.85	15.24	4.72	46.48	69.00	8.50	875.50
96	96	78.00	94.50	29.80	127.00	105.90	10.90	21.20	45.70	31.70	39.50	12.19	5.63	2.78	14.20	4.43	49.52	74.40	5.50	887.30
97	97	78.50	88.00	33.00	122.50	102.70	12.50	20.20	48.30	42.20	43.60	16.87	7.03	3.12	17.07	5.03	48.31	63.10	5.50	892.30
98	98	80.50	94.50	36.10	125.50	110.70	13.00	21.50	62.00	40.40	43.50	17.41	6.75	3.28	16.85	5.26	48.75	69.70	8.50	969.30
99	99	80.00	92.50	32.20	127.00	90.00	11.50	19.70	55.20	36.40	43.40	17.48	6.55	3.14	16.23	4.59	45.88	77.50	6.00	694.30
100	100	73.50	85.00	37.20	121.50	131.90	11.80	18.70	44.70	48.50	42.30	19.53	7.19	3.27	17.71	5.28	43.77	69.70	6.50	956.30
101	101	72.00	86.50	34.20	123.00	101.00	11.90	18.00	46.30	41.10	44.30	17.41	6.83	3.27	17.00	5.17	47.68	56.90	6.50	1098.60
102	102	75.00	88.00	41.80	125.00	105.90	12.10	20.40	47.50	46.60	38.20	14.31	5.89	3.16	14.94	4.98	46.41	69.70	6.50	760.60
103	103	76.20	92.00	29.60	126.50	131.40	10.10	19.00	38.40	44.40	36.60	17.42	6.43	3.23	16.16	5.19	49.35	66.60	4.00	992.60
104	104	75.00	92.00	38.30	126.00	103.90	12.40	20.50	47.80	41.50	37.30	13.02	6.34	2.88	15.50	4.64	49.61	66.40	7.50	872.60
105	105	74.00	89.50	30.70	129.00	106.00	11.90	18.70	41.90	49.30	46.20	18.41	6.66	3.37	16.73	5.15	49.82	70.50	7.00	950.60
106	106	78.50	94.00	29.10	129.50	92.50	9.40	20.00	43.70	34.00	40.30	17.26	6.61	3.07	16.26	4.89	48.63	71.90	5.50	653.60
107	107	81.00	96.50	41.30	131.50	120.50	13.40	22.40	57.80	40.40	40.10	14.29	6.52	2.87	16.02	4.77	52.18	68.00	8.00	906.40
108	108	76.50	88.00	23.50	124.50	107.50	11.90	20.40	41.50	51.10	41.50	17.11	6.42	2.95	15.87	4.60	51.12	68.00	7.00	873.60
109	109	77.50	86.00	37.20	122.00	108.50	11.80	20.00	47.50	43.40	42.10	13.65	6.29	2.56	15.19	4.68	54.40	64.60	8.00	973.60
110	110	79.00	88.00	41.90	123.50	98.90	11.40	18.50	53.90	42.40	41.90	11.44	5.92	2.95	14.92	4.72	49.38	68.00	6.00	1028.60
111	111	75.00	90.50	25.90	125.50	103.00	11.10	18.40	51.30	48.00	49.40	17.50	6.85	3.19	17.04	5.17	46.30	66.40	9.00	1020.60
112	112	78.00	93.00	38.30	126.00	112.20	12.90	20.20	44.50	52.10	42.30	16.75	6.97	3.17	17.21	5.08	47.10	63.70	9.00	1111.60
113	113	94.50	107.00	44.63	141.00	98.05	10.85	18.40	58.20	30.15	35.58	19.52	6.63	3.14	16.41	4.92	48.40	69.30	8.00	713.50
114	114	90.00	103.00	36.36	142.50	74.65	10.49	17.90	57.30	38.55	39.91	17.19	6.58	3.00	16.14	4.67	48.41	76.20	7.00	567.50
115	115	87.00	101.00	36.13	137.50	101.65	11.39	19.40	54.60	40.80	42.56	16.35	6.75	2.99	16.50	4.61	51.92	66.50	5.50	514.50
116	116	77.00	90.00	30.30	124.00	107.30	10.70	20.20	42.40	45.30	40.50	16.32	6.84	3.08	16.80	5.12	47.95	53.20	5.00	879.30
117	117	81.00	97.00	37.80	128.50	94.00	11.20	22.20	57.70	37.30	41.50	17.13	6.63	3.04	16.39	4.93	49.20	61.10	6.50	846.30
118	118	82.00	94.00	28.20	127.00	98.90	11.10	19.40	45.30	38.50	38.90	16.06	6.70	3.28	16.68	5.48	45.43	64.40	2.50	848.30
119	119	77.00	93.00	30.80	128.00	89.50	11.60	21.20	47.40	34.60	40.10	17.62	6.77	3.30	16.90	5.11	47.32	57.80	5.50	836.30
120	120	78.00	91.00	32.30	125.50	102.20	12.20	20.70	62.80	38.60	42.70	18.62	6.55	3.03	16.25	4.59	57.01	61.50	7.50	850.30
121	121	76.00	88.00	33.10	121.50	99.50	11.00	17.40	52.30	42.10	45.40	19.24	6.80	3.19	16.89	5.17	50.38	58.00	5.50	951.30
122	122	73.00	84.00	37.90	121.50	107.90	11.50	18.90	52.00	44.60	42.80	19.50	7.23	3.42	17.93	5.63	48.60	57.20	8.50	896.30
123	123	75.50	88.00	33.30	125.00	106.20	11.10	21.20	44.70	50.50	43.40	18.20	6.54	3.22	16.36	5.05	42.89	66.70	6.50	1064.30
124	124	72.00	87.50	40.70	124.00	99.40	11.30	18.70	44.50	52.20	42.70	18.09	6.56	3.40	16.68	4.80	47.59	50.00	6.00	982.30
125	125	80.00	95.50	36.00	129.00	105.50	12.60	19.40	44.90	42.60	34.40	16.36	6.66	3.16	16.47	4.69	48.50	58.90	1.00	645.30
126	126	73.00	92.00	21.90	127.00	99.20	11.10	20.70	50.20	32.90	42.80	18.40	7.06	3.25	17.43	5.44	47.78	77.10	7.50	736.10
127	127	74.50	91.50	35.90	126.50	101.20	12.30	20.20	39.30	35.00	32.50	14.36	6.25	2.95	15.57	4.55	44.33	72.50	7.50	699.10
128	128	73.00	92.00	34.40	126.00	104.50	12.60	19.70	56.10	40.70	38.70	12.31	5.71	2.67	14.20	4.11	43.32	72.00	6.50	603.10
129	129	68.00	86.50	26.70	124.00	123.40	9.60	16.00	27.90	40.70	30.10	15.34	6.59	3.12	16.42	5.09	40.92	68.20	4.50	634.10
130	130	83.00	98.50	37.70	128.00	150.90	11.80	19.20	44.90	35.80	27.70	15.78	7.06	3.25	17.31	4.90	49.11	70.80	4.50	662.10
131	131	78.40	90.00	40.30	124.50	90.70	9.00	19.70	42.00	50.00	35.20	17.93	7.16	3.17	17.44	4.83	44.42	68.40	7.50	633.10
132	132	77.00	91.50	34.00	125.00	115.40	10.70	19.70	53.70	37.50	41.50	17.65	6.89	3.21	17.00	5.09	37.29	66.90	7.50	920.10
133	133	77.00	93.00	38.80	126.50	99.70	12.10	21.20	63.70	36.30	41.20	18.51	7.36	3.46	18.17	5.60	45.73	66.30	6.00	913.10

134	134	75.00	92.00	25.90	124.50	84.90	9.40	20.00	53.60	34.00	46.30	12.45	5.92	2.65	14.54	4.42	39.97	72.10	8.50	890.10
135	135	70.00	92.50	28.90	127.00	103.70	12.00	22.70	53.60	39.70	38.40	16.42	6.78	3.15	16.82	5.06	47.95	69.70	8.50	762.00
136	136	76.00	92.00	48.20	124.00	117.50	11.90	21.50	47.10	41.30	39.40	18.40	7.07	3.26	17.52	5.13	36.64	67.60	7.50	748.80
137	137	81.00	92.00	50.10	125.50	100.70	12.50	21.20	53.10	36.20	38.20	16.03	6.77	2.89	16.40	5.11	51.23	72.10	7.50	723.80
138	138	77.00	92.50	50.90	126.00	122.20	12.70	22.50	48.00	47.10	36.40	16.25	6.55	3.18	16.38	4.90	49.75	77.10	4.50	890.80
139	139	79.00	92.00	77.00	128.00	100.90	15.10	24.00	71.20	49.70	36.80	15.59	6.36	3.07	16.00	4.83	40.28	65.20	8.00	765.80
140	140	75.00	91.50	65.50	125.00	124.90	14.10	21.90	52.20	51.80	36.20	18.46	7.24	3.35	17.82	5.44	47.69	67.10	1.50	889.80
141	141	72.00	88.50	38.20	121.00	126.20	8.70	20.40	31.30	39.30	29.20	17.07	6.83	3.18	16.83	4.85	47.19	63.90	2.00	529.80
142	142	73.00	89.00	61.90	126.00	90.50	12.30	23.00	58.60	48.50	42.70	16.92	7.00	3.32	17.34	5.64	45.33	77.10	7.00	775.80
143	143	85.00	98.50	52.80	132.50	100.50	13.90	21.90	64.00	41.10	37.10	19.35	7.35	3.50	18.29	5.72	50.79	71.80	6.00	784.80
144	144	78.00	94.00	39.30	127.00	106.40	11.50	22.20	56.90	47.70	44.20	17.06	6.54	2.98	16.09	4.35	44.82	67.30	7.00	914.80
145	145	75.00	88.00	34.20	124.00	89.50	11.10	19.00	40.50	47.10	50.60	17.46	6.78	3.08	16.58	4.96	45.14	60.60	6.00	908.80
	Mean all	85.04	98.39	38.00	132.85	110.69	10.94	19.77	51.90	37.83	38.73	16.35	6.66	3.12	16.47	4.98	47.08	65.99	6.22	790.07
	Min	68.00	83.40	21.90	121.00	74.65	7.95	16.00	27.90	17.30	21.60	11.44	5.63	2.56	14.20	4.11	35.88	50.00	1.00	175.50
	max	116.00	122.50	77.00	153.50	150.90	15.60	24.00	71.20	52.20	50.60	20.24	8.20	3.50	19.47	5.83	57.92	77.50	10.00	1203.80
	Std. Error	1.316	1.000	1.265	0.835	1.433	0.448	0.319	1.140	1.172	0.759	0.444	0.159	0.105	0.227	0.156	0.585	0.891	0.753	5.884

Table 3: Correlation coefficient for 19 morpho-physiological and yield related traits in wheat

Character	DTB	DTF	FLA (mm2)	PM	PH (cm)	SL	NSS	NGS	TGW	HI (%)	SA (mm2)	SL (mm)	SB (mm)	SP (mm)	SAL	CC	MSI (%)	PW	YPP (g)
DTB	1.000	0.958**	0.140	0.954**	0.439**	-0.551**	-0.263**	0.428**	-0.752**	-0.297**	-0.112	0.056	-0.025	0.042	0.048	0.249**	-0.110	0.041	-0.409**
DTF		1.000	0.163*	0.965**	0.430**	-0.510**	-0.211**	0.422**	-0.762**	-0.389**	-0.134	0.023	-0.038	0.013	0.002	0.209*	-0.073	0.043	-0.479**
FLA (mm2)			1.000	0.158	0.155	0.275**	0.318**	0.242**	0.098	-0.264**	0.011	0.056	0.036	0.060	0.055	-0.038	0.071	-0.002	-0.029
PM				1.000	0.411**	-0.593**	-0.284**	0.421**	-0.738**	-0.327**	-0.089	0.059	-0.017	0.048	0.059	0.217**	-0.049	0.048	-0.474**
PH (cm)					1.000	-0.214**	-0.104	0.024	-0.311**	-0.461**	-0.047	0.070	0.064	0.077	0.125	0.115	-0.156	-0.108	-0.208*
SL						1.000	0.576**	-0.083	0.509**	0.080	-0.047	-0.127	-0.023	-0.116	-0.141	-0.116	0.121	0.038	0.323**
NSS							1.000	0.256**	0.207*	0.044	-0.133	-0.158	-0.147	-0.166*	-0.120	-0.102	0.218**	0.100	0.184*
NGS								1.000	-0.378**	0.089	-0.065	-0.016	-0.063	-0.026	0.027	0.094	-0.045	0.194*	0.034
TGW									1.000	0.334**	0.160	0.006	0.100	0.027	-0.019	-0.130	0.051	-0.100	0.354**
HI (%)										1.000	0.149	0.026	-0.064	0.010	-0.001	-0.076	0.085	0.169*	0.375**
SA (mm2)											1.000	0.733**	0.751**	0.803**	0.578**	-0.003	-0.043	0.046	0.107
SL (mm)												1.000	0.576**	0.978**	0.754**	0.034	-0.100	-0.040	-0.028
SB (mm)													1.000	0.720**	0.588**	0.032	-0.123	-0.011	0.047
SP (mm)														1.000	0.774**	0.041	-0.111	-0.020	-0.013
SAL															1.000	-0.002	-0.050	0.035	0.025
CC																1.000	-0.126	-0.035	-0.053
MSI (%)																	1.000	0.011	-0.063
PW																		1.000	0.061
YPP (g)																			1.000

Correlation studies

The correlation analysis revealed several significant relationships among the studied traits (Table 3). Days to booting (DTB) showed a strong positive correlation with days to flowering (DTF) (r = 0.958**) and plant maturity (PM) (r = 0.954**), while it was negatively correlated with spike length (SL) (r =-0.551**) and thousand grain weight (TGW) (r =-0.752**). Similarly, days to flowering (DTF) exhibited significant positive associations with plant maturity (PM) (r = 0.965**) and a negative correlation with TGW (r =-0.762**).Flag leaf area (FLA) showed moderate positive correlations with traits like spike length (SL) (r = 0.275**) and number of spikelets per spike (NSS) (r = 0.318**). Plant height (PH) was negatively associated with traits like harvest index (HI) (r =-0.461**) and TGW (r =-0.311**). Spike length (SL), on the other hand, had strong positive correlations with number of spikelets per spike (NSS) (r = 0.576**) and grain yield per plant (YPP) (r = 0.323**).Thousand grain weight (TGW) showed a significant positive correlation with harvest index (HI) (r = 0.334**) and yield per plant (YPP) (r = 0.354**). Among spike morphometric traits, spike area (SA) had strong positive correlations with spike length (SL) (r = 0.733**), spike breadth (SB) (r = 0.751**), and spike peduncle length (SP) (r = 0.803**).These findings highlight the intricate relationships among the traits, which could be useful for selecting specific traits in wheat breeding programs, particularly those aimed at improving yield and stress tolerance.

Conclusion

The analysis of variance (ANOVA) conducted on the various wheat genotypes provided compelling evidence of significant differences in key agronomic traits, underscoring the genetic variability present in the population studied. The highly significant "Block" effects (p<0.01) for all traits suggest that environmental factors played a critical role in influencing these traits, while significant "Treatment" effects (p<0.01) further emphasized the responsiveness of the wheat genotypes to differing conditions. The notable differences between "Checks" and "Test Entries" highlighted the potential for selecting superior genotypes under varying circumstances, thereby facilitating targeted breeding efforts. The mean performance analysis reinforced these findings, identifying specific genotypes—such as genotype 4, which excelled in multiple traits including leaf area and total grain weight, and genotype 45, which demonstrated early booting and flowering traits—as prime candidates for selection in breeding programs. These results not only illustrate the potential of genetic selection to enhance desirable traits but also emphasize the importance of environmental context in agricultural productivity (Khan *et al*., 2020; Ali *et al*., 2019) [2, 1]. Additionally, the correlation studies revealed complex interrelationships among traits, with high correlations among critical yield components such as days to booting, flowering, and plant maturity. This knowledge can guide breeders in making informed decisions regarding trait selection for yield improvement and stress resilience (Singh *et al*., 2021) [3].

The significant positive and negative correlations among various traits also underscore the importance of considering these relationships in breeding strategies aimed at enhancing overall wheat performance.

References

1. Ali Q, Khan MA, Khatak MI. Genetic variability and correlation among various agronomic traits in wheat (*Triticum aestivum* L.) genotypes. International Journal of Agriculture and Biology. 2019;21(2):287-294.
2. Khan MA, Bhat SK, Ali Q. Effect of environmental factors on the performance of wheat genotypes. Wheat Research Journal. 2020;9(1):1-10.
3. Singh R, Yadav SK, Kumar A. Trait associations and their implications in wheat improvement: A review. Journal of Cereal Science. 2021;100:103-112.
4. Hiferaw B, Prasanna BM, Hellin J, Banziger M. Crops that feed the world 2. Part 1. Producing wheat and maize in the face of climate change. Food Security. 2013;5(1):35-50.
5. Shewry PR, Hey SJ. Relationships between wheat grain composition and processing quality. Journal of Cereal Science. 2015;63(3):287-297. https://doi.org/10.1016/j.jcs.2015.03.006
6. Food and Agriculture Organization of the United Nations. FAO Statistical Database. Rome: FAO; 2021. Available from: http://www.fao.org/faostat/en/#data/QC
7. International Maize and Wheat Improvement Center (CIMMYT). Wheat and climate change. Mexico City: CIMMYT; 2021. Available from: https://www.cimmyt.org/wp-content/uploads/2021/03/CIMMYT-Wheat-and-Climate-Change.pdf
8. Government of India. Agricultural Statistics at a Glance. New Delhi: Ministry of Agriculture and Farmers Welfare; 2019. Available from: http://eands.dacnet.nic.in
9. Tripathi AK, Mishra AK. An overview of wheat production in India: Present status and future prospects. Indian Journal of Agricultural Sciences. 2017;87(10):1296-1304.
10. Food and Agriculture Organization of the United Nations. The future of food and agriculture-Trends and challenges. Rome: FAO; 2017.
11. Ortiz R, Sayre K, Govaerts B, Gupta R. Climate change: Can wheat beat the heat? Nature. 2008;456(7219):213-215.