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Stability for earliness in wheat

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Abstract
Stable early-maturing wheat varieties serve as a critical buffer against terminal heat, drought, and pest cycles, enabling higher market premiums and reduced operational costs in multi-cropping systems. The present research entiled stability for earliness was conducted during Rabi 2024-25 across three locations Dhule, Rahuri, and Niphad using the Eberhart and Russell model. The genotypes showed significant differences for both traits when tested against pooled error. The environments differed significantly for days to 50% heading and days to maturity when tested against pooled deviation, pooled error and G X E interaction. Significant G × E interactions confirmed that genotypes performed differently across all locations. Rahuri was favourable for early heading. Niphad and Dhule favoured earlier maturity. NIAW-4820, NIAW-4857, NIAW-4864, NIAW-4887, NIAW-4891 and NIAW-4898 had average stability for days to 50% heading. NIAW-4809 and NIDW-1585 showed average stability for days to maturity. NIAW-4840 had above - average stability for days to 50% heading. NIAW-4820, NIAW-4901, and MACS-6222 [C] showed above-average stability for days to maturity. NIAW-4910 showed below-average stability for days to 50% heading. NIAW-4840, NIAW-4857, NIAW-4871, NIAW-4887 and NIAW-4891 showed below-average stability for days to maturity, indicating specific adaptation to high-yielding environments.

Keywords: Days to 50% heading, days to maturity, wheat, stability, G x E interaction, above -average stability, below- average stability, average stability, earliness

Introduction
Early maturity acts as an escape mechanism against late-season droughts, terminal heat stress, and pest cycles. A stable early-maturing crop will always complete its life cycle before these adverse environmental conditions peak. Maharashtra produces 35.10 lakh tonnes of wheat across an area covering 15.27 lakh hectares. (Anonymous,2026) [1]. The Eberhart and Russell model mathematically dissects phenotypic performance across test environments using three primary criteria i.e. the genotypic mean yield, the linear regression coefficient (bi), and the deviation from regression mean square (S^2di) (Nyol *et al*., 2025) [10]. According to this mathematical structure genotypes that maintain a high mean yield paired with a unit regression coefficient and a non-significant, near-zero deviation demonstrate predictable behavior and robust stability across wide geographical or temporal ranges (Eskezia *et al*., 2026) [6]. In regions like Maharashtra, farmers rely heavily on multi-cropping sequences (such as planting a winter crop after the monsoon harvest). If a variety's earliness is stable, farmers can perfectly time the harvest and immediately plant the next crop without delay. Early-season produce typically fetches a premium market price. If the earliness is unstable and fluctuates, farmers cannot synchronize their harvests to coincide with these lucrative, early-market windows. Crops with a stable, short growing cycle require less water, fertilizer, and fewer pesticide applications, directly lowering operational costs while ensuring the plant reaches maximum yield. In modern agriculture, early-maturing crop varieties act as a critical buffer against climate unpredictability and market fluctuations. Keeping this view in mind, the present investigation was carried out.

Materials and Methods
The present research, entitled "Stability for earliness in wheat" was conducted at three locations *viz*., Agricultural Research Station, Government college of Agriculture, Dhule, Post Graduate Institute farm, MPKV Rahuri and Agricultural Research Station, Niphad during

Rabi 2024-25 in a randomized block design with three replications. The data from each of these locations were recorded on the number of days to 50 per cent heading, days to maturity. Line sowing was practiced with a row spacing of 20 cm. The gross plot size was 6.00 m × 1.20 m (6 rows), while the net plot size was 6.00 m × 0.80 m (4 rows). A uniform fertilizer dose of 120:60:40 kg NPK/ha was applied alongside standard agronomic practices. Stability analysis based on the Eberhart and Russell, (1966) [5] and Panse and Sukhatme, (1967) [11] model were undertaken using INDOSTAT statistical package at Bajra Research Scheme, Dhule.

Results and discussion

The genotypes exhibited significant differences for both traits days to 50% heading and days to maturity when tested against pooled error (Table -1), confirming a diverse genetic base in the experimental material. The environments differed significantly for days to 50% heading and days to maturity when tested against pooled deviation, pooled error and G X E interaction indicating a high degree of variability between the three locations. G × E interaction was found significant for both characters days to 50% heading and days to maturity when tested against pooled error. Hence stability analysis performed for these two traits. The G X E interactions were significant for both linear and non- linear components across days to 50% heading except for days to maturity. When tested against pooled deviation and pooled error, the environment (linear) effect was found to be significant for both characters. E + G X E effect was significant for the traits *viz.*, days to 50 per cent heading, days to maturity when tested against pooled deviation and pooled error. The significant differences between genotype and environment for major wheat characters were also found in earlier studies by Bains and Gupta (1972) [4], Krupal (2017) [8], Rathod (2018) [13] and Patil (2021) [12].

Bains and Gupta (1972) [4], Kishor *et al.* (1992) [7], Mehta *et al.* (2000) [9], Ashraf *et al.* (2001) [3], and Rathod (2018) [13], Patil (2021) [12] had significant linear and non-linear components of G × E interactions for the majority of characters investigated in wheat. Negative environmental indices at Rahuri location, indicated that it was the favorable location for days to 50% heading. (Table-2) Rahuri location, provided a favorable environment for late maturity, whereas Niphad location and Dhule location tended to favor earlier maturity.

Average stability for days to 50% heading was observed in NIAW-4820, NIAW-4857, NIAW-4864, NIAW-4887, NIAW-4891 and NIAW-4898. (Table -3) For days to maturity genotypes NIAW-4809 and NIDW-1585 showed average stability. (Table -4) All above mentioned genotypes had higher mean than parental mean and non-significant regression coefficient and deviation from regression (Mean>population mean, bi=1.00 ns and S^2di=0 ns) and grouped as average stable for both characters and would be well adapted to all of environments.

Genotype NIAW-4840 showed above-average stability for days to 50% heading. (Table-3) Genotypes NIAW-4820, NIAW-4901, and MACS-6222[C] showed above-average stability for days to maturity. (Table -4). All above mentioned genotypes followed the criteria for above - average stability (i.e. Mean>population mean, bi<1.00 and significant and S^2di=0 ns) and might be adopted to poor environment.

The genotypes NIAW - 4910 showed below average stability for days to 50% heading. (Table -3) The genotypes NIAW-4840, NIAW-4857, NIAW-4871, NIAW-4887 and NIAW-4891 showed below average stability for days to maturity. (Table -4) All above mentioned genotypes followed the criteria for below-average stability. (i.e. Mean>population mean, bi>1.00 and significant and S^2di=0 ns) and suitable for poor environment.

These findings regarding days to 50 percent heading align with those previously reported by Thakare (2014) [14] and Krupal (2017) [8]. Similar results for days to maturity were obtained by Krupal (2017) [8] and Rathod (2018) [13].

Table 1: ANOVA for stability as per Eberhart and Russell Model (1966) [5] in wheat.

Sr. No.	Sources	Degrees of freedom	Days to 50% heading	Days to maturity
1)	G	23	30.50 @@##**	7.92**
2)	E	2	43.19 @@##**	493.82@@##**
3)	G X E	46	4.92**	5.47**
4)	E + G X E	48	6.52##**	25.82##**
5)	E (L)	1	86.38##**	987.64##**
6)	G X E (L)	23	6.64#**	3.98
7)	P.D. (Pooled deviation)	24	3.08**	6.67**
8)	P.E. (Pooled error)	144	1.48	3.13

@, @@: Significant at 5 and 1% level of significance, respectively against G × E
#,##: Significant at 5 and 1% level of significance, respectively against the pooled deviation (PD)
*, **: Significant at 5 and 1% level of significance, respectively against the pooled error (PE)

Table 2: Estimation of environment index (Ij) under different environments

Sr. No.	Sources	Environmental index (Ij)		
		Dhule	Niphad	Rahuri
1	Days to 50% heading	1.537	-0.935	-0.602
2	Days to maturity	-1.787	-3.370	5.157

Table 3: Estimates of stability parameters for days to 50 per cent heading

Sr. No	Genotypes	Days to 50 per cent heading		
		$\bar{X}$	bi	S^2di
1	NIAW-4804	61.89	-1.045	12.880**
2	NIAW-4809	64.56	1.702	1.051
3	NIAW-4820	60.11	-0.148	-0.155
4	NIAW-4822	64.11	2.308**	-1.478
5	NIAW-4828	63.44	0.508	-0.337
6	NIAW-4834	64.00	2.135**	-1.226
7	NIAW-4840	61.56	0.910**	-1.278
8	NIAW-4848	55.11	-1.839	6.425*
9	NIAW-4857	60.78	0.402	-1.103
10	NIAW-4864	55.00	-1.158	3.249
11	NIAW-4871	65.78	2.736**	-1.453
12	NIAW-4881	62.44	0.539	-1.120
13	NIAW-4887	59.44	-1.015	3.103
14	NIAW-4888	63.22	1.720	2.385
15	NIAW-4891	61.22	0.835	1.413
16	NIAW-4898	61.56	0.575	-0.379
17	NIAW-4901	63.22	0.954	7.985*
18	NIAW-4910	61.22	1.337**	-1.175
19	NIDW-1585	62.22	2.327*	2.429
20	NIDW-1590	67.33	3.051**	-1.433
21	NIDW-1591	65.67	2.717**	1.510
22	P. Samadhan (C)	57.22	1.126	6.472*
23	MACS-6222 (C)	62.33	2.699*	1.861
24	NIDW-295(C)(D)	67.00	0.625**	-1.334
Mean		62.10		
SE ±		1.24		

*, **Significant at 5% and 1% level, respectively.

Table 4: Estimates of stability parameters for days to maturity

Sr. No	Genotypes	Days to maturity		
		$\bar{X}$	bi	S^2di
1	NIAW-4804	106.89	0.815	13.175*
2	NIAW-4809	107.11	0.574	0.286
3	NIAW-4820	106.11	0.937*	4.379
4	NIAW-4822	108.33	0.985**	-2.824
5	NIAW-4828	109.33	0.998**	-2.093
6	NIAW-4834	110.00	0.916**	-2.977
7	NIAW-4840	107.67	1.092**	1.316
8	NIAW-4848	112.33	1.118*	6.093
9	NIAW-4857	107.67	1.755**	0.847
10	NIAW-4864	104.67	0.987	37.678**
11	NIAW-4871	105.89	1.224**	-2.299
12	NIAW-4881	106.33	1.006	10.147*
13	NIAW-4887	106.56	1.380**	2.100
14	NIAW-4888	108.44	1.195**	-2.972
15	NIAW-4891	107.67	1.146*	5.738
16	NIAW-4898	108.89	1.552**	-0.616
17	NIAW-4901	106.00	0.890**	-2.849
18	NIAW-4910	107.67	1.006	10.147*
19	NIDW-1585	107.22	0.662	1.361
20	NIDW-1590	109.89	0.312	8.949
21	NIDW-1591	108.44	0.750**	-3.115
22	P. Samadhan(C)	108.33	0.622*	-1.038
23	MACS-6222(C)	106.78	0.906**	-0.856
24	NIDW-295(C)(D)	108.00	1.174*	4.343
Mean		107.80		
SE ±		1.83		

*, **Significant at 5% and 1% level, respectively.

Table 5: Nature of stability of wheat genotypes under different environments

Sr. no.	Character	Genotypes showing stability			Unstable (S2di significant and High mean)
		Average stability (suitable for all environments)	Below average stability (bi>1) (suitable for rich environment)	Above average stability (bi<1) (suitable for poor environment)	
1	Days to 50 Percent Heading	NIAW-4820, NIAW-4857, NIAW-4864, NIAW-4887, NIAW-4891, NIAW-4898	NIAW - 4910,	NIAW-4840	NIAW-4804, NIAW-4848, P. Samadhan(C)
2	Days to Maturity	NIAW-4809 NIDW -1585	NIAW-4840, NIAW-4871, NIAW-4887, NIAW-4891, NIAW-4857	NIAW-4820, NIAW-4901, MACS-6222(C)	NIAW-4804, NIAW-4864, NIAW-4881, NIAW-4910

Conclusion

The evaluated genotypes possess a highly diverse genetic base, showing significant differences for both days to 50% heading and days to maturity. Rahuri represents a favourable location for days to 50% heading. Niphad and Dhule favour earlier maturity. Significant Genotype × Environment (G × E) interactions confirm that genotypes perform differently across locations, validating the need for stability analysis. The genotypes NIAW-4820, NIAW-4857, NIAW-4864, NIAW-4887 and NIAW-4898 showed average stability for days to 50% heading while for days to maturity genotypes NIAW-4809 and NIDW-1585 showed average stability. The genotype NIAW-4840 had above average stability for days to 50% heading and for days to maturity the genotypes NIAW-4820, NIAW-4901, MACS-6222[C] showed above average stability. Below average stability was shown by the genotype NIAW-4910 for the days to 50% heading while the genotypes NIAW-4840, NIAW-4857, NIAW-4871, NIAW-4887 and NIAW-4891 showed below average stability for days to maturity.

Authors' contribution

Conceptualization of research (SSS, VYP, KKB, JMP, NMM); Designing of experiments (SSS, VYP, KKB, JMP, NMM); Contribution of experimental material (NMM, VYP,); Execution of field experiments and data collection (SSS, SSK, MGB, NSG); Analysis of data and interpretation (SSS, VYP, NMM); Preparation of manuscript (SSS, VYP).

Declaration

The authors declare no conflict of interest.

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