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Estimation of genetic variability, heritability and genetic advance for qualitative and quantitative traits under normal and late sown condition in bread wheat (*Triticum aestivum* L.)

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Abstract
Thirty genotypes were evaluated for genetic variability, heritability and genetic advance under normal and late sown conditions at the research farm of Department of Genetics and Plant Breeding, JNKVV, Jabalpur (M.P.). The experimental material consist of 30 genotype including 5 checks *viz.,* MP 3288, MP3336, MP 3382 GW322 and JW3211. Analysis of observed data showed that mean square due to treatments for all the traits in both the environment were highly significant. GCV and PCV were highest for peduncle length, grain yield per plant, sedimentation value and number of tillers per plant, in late sown condition, peduncle length, number of ear per plant, ear weight, sedimentation value and number of tillers per plant, indicated the presence of sufficient variability in the existing material. The estimate of genetic advance were highest for sedimentation value, peduncle length and grain yield per plant high heritability coupled with high genetic advance as percentage of mean for both normal and late sown condition. This study suggested that the presence of adequate genetic variability, heritability and genetic advance for these traits under normal and late sown environment is suitable for breeding programme and crop improvement. Therefore, selection for such traits may be rewarding.

Keywords: Wheat, analysis of variance, heritability and genetic advance

Introduction
Wheat is world's second most important staple crops of the world which is grown more than 17% of the cultivable land and is consumed by nearly 35% of the global population next to rice. Wheat fulfills 21% of the protein requirements of more than 4.5. Billion population in developing countries. In year (2016-17) wheat production was 97.44 mt with an average national productivity of 3172 kg/ha Anonymous (2017) [1]. Wheat is very sensitive to high temperature and moisture stress and one of the reasons for low production. There is a lack of high yielding varieties, which are suitable for terminal heat under normal and late planting condition. At present; breeding of wheat for such specific situation including identification of potential and most promising genotypes and related attributes on variability, association and co-inheritance keeps immense values. There is great scope to increase wheat production in normal and even in late sown conditions by application of suitable breeding tools to evaluate more efficient plant genotypes and varieties. Heat is an important stress that restricts wheat production and productivity, both during germination and grain filling periods because wheat crop is adapted for cultivation in regions with cooler climate conditions. Therefore, its cultivation in warmer climates is restricted to cooler months of the year (i.e., winter season). It is estimated that "cool period" for wheat crop in India is shrinking, while the threat to terminal heat stress is increasing. Recent years, wheat breeding has concentrated on increased yield, earliness, grain quality and disease resistance especially the leaf and stem rust. India has made tremendous progress in wheat production and productivity by evolving high yielding varieties. It has been believed that complex physiological process determine yield and there is a great role of environment, which influence the yield. Temperature and short winter growing season in central, it has been expected that early sowing of wheat may escape from high temperature during grain filling but high temperature at the time of sowing affects germination and early vegetative growth. Therefore, identification of wheat genotype having variability suitable for specific sowing condition is of great importance for achieving higher yield.

The development of an effective plant breeding programme is dependent on genetic variability. The selection efficiency dependent on overall variability present in plant population. Thus, in any population improvement programme the success deponent on nature of variability present for such a plant breeder should be very judicious in selection programme. Heritability along with genetic advance is more helpful in selection procedure then heritability alone. High heritability along with high genetic advance reveals strong contribution of additive variance for expression of the trait and such trait play more important role in improving grain yield. The objective of this research study was to estimate genetic variability, heritability and genetic advance under both normal and late sown condition which can be use in breeding and crop improvement programme.

Material and Method

This investigation was carried out at Seed Breeding Farm, Department of Plant Breeding and Genetics College of Agriculture, JNKVV, Jabalpur (M.P).Experimental material consist of 30 genotype including 5 checks *viz.*, GW322, JW3211, MP3288, MP3336 and MP3382 obtained from Wheat Improvement Project, JNKVV Jabalpur (M.P.) during *Rabi* (2017-18). The experiment was conducted with three replication under RBD for normal and late date of sowing. Standard agronomic practices were adopted in each experiment to raise a good crop. Observations were recorded on five plants which are randomly selected from each genotype for various quantitative characters. Observations were recorded on five plants which are randomly selected from each genotype for various quantitative traits *viz.*, days to 50% flowering, days to maturity, plant height, number of effective tillers, number of ears per plant, number of spikelet per spike, ear length, ear weight, peduncle length, biological yield per plant, grain yield per plant, 1000-grain weight, harvest index, canopy temperature, chlorophyll content, relative water content, sedimentation value, protein and starch percent.

Statistical analysis

Statistical analysis was carried out using the mean value of individual genotype under normal and late sown condition at 0.05% of probability level. Recorded data for both normal and late sown conditions were need to statistically analyze and analysis is done by using statistical software WINDOSTAT programme. Genetic variability was estimated and suggested by Burton (1953), heritability was suggested by Hanson (1956) [6]. and Genetic Advance was estimated by Johnsen *et al.* (1955).

Results and Discussion

Analysis of variance

The result of analysis of variance for characters under both normal and late sown condition detailed in table 2 & 3. The mean squares due to treatments for all characters in both normal and late sown condition were highly significant, therefore considering the presence of considerable amount of variability among 30 wheat genotype for 19 characters. The analysis of variance results showed similar finding of Kabir *et al.* (2017) [10]. and Rajdeep *et al.* (2014) [14]. for all 19 yield attributing traits.

Variability

Genetic variability among existing varieties is highly useful. Variability is the basic requirement for successful breeding programme to achieve self-sufficiency and susceptibility. Heat stress is known to adversely affect many traits resulting into decline in grain yield. There is defiantly need to develop cultivar with diverse genetic base. The higher estimation of PCV, suggested that adequate variability is present for these traits and there should apply appropriate breeding programme for bringing improvement in heat stress conditions.

Genotypic and phenotypic coefficient of variation for yield and yield contributing characters are summarized in Table 4 & 5 for both normal and late sown condition respectively. The phenotypic coefficient of variation was higher in magnitude than that of genotypic coefficient of variation for all the characters under study. In normal sown condition, peduncle length recorded the highest PCV (18.78) followed by grain yield per plant (13.87) sedimentation value (12.51) Number of tillers per plant(10.42) number of spikes per plant (8.61), protein% (7.19), ear weight (9.11), ear length (9.75), chlorophyll content (7.77), harvest index (9.14),, number of spikelet per spike (5.02%), Biological yield per plant (6.58), days to 50% heading (6.71), plant height (6.14), relative water content (5.45), canopy temperature (4.53),1000-grain weight (5.22), days to maturity (4.35), starch percent (1.99).

In Late sown condition, phenotypic coefficient of variation was higher in magnitude than that of genotypic coefficient of variation for all the characters under study. Peduncle length recorded the highest PCV and GCV (17.92) followed by ear weight (16.39), sedimentation value (13.41), number of tillers per plant(12.43), chlorophyll content (8.66), number of spikes per plant (7.96), thousand grain weight (8.78), grain yield per plant (8.22), ear length (6.18), number of spikelet per ear (7.96), harvest index (6.71), biological yield per plant (6.52), plant height (5.75), relative water content (5.50), protein (5.47), canopy temperature (4.89), days to maturity (4.13), days to 50% heading (3.70), and starch (2.05).

Therefore it was concluded that the degree of variability present in wheat for various traits and their results follows similar variability pattern *i.e.*, higher GCV and PCV for grain yield per plant ear length, harvest index, number of ear per plant, days to 50% heading, biological yield per plant, as per according to previous findings of Rathwa (2018) [15], Arya (2017) [2]. and Phougat *et al.* (2017) [16]. thousand grain weight, number of spikelet per spike, number of tillers per plant by Dharmendra & Singh (2015) [5]. and Kyosev *et al.* (2015) [12]. conformed similar results in *Triticum aestivum* but different genotypes.

Heritability (%) and Genetic Advance as percentage of mean

The coefficient of variation indicates only the extent of variability existing for various traits but does not give any information regarding heritable portion of it. Amount of high or moderate heritability accompanied with high or moderate genetic advance indicates additive gene action involved in the inheritance of concerned traits, hence selection may be effective. The knowledge of heritability is helpful in assessing merits and demerits of a particular trait as it enables the plant breeder to decide the course of selection procedures to be followed under a given situation.

The estimate of heritability and expected genetic advance for nineteen traits of wheat verities in timely and late sown conditions are presented in table 4 & 5. In normal sown condition, high heritability was obtained for sedimentation value (99.99), followed by plant height (99.74), days to maturity (99.30), days to 50% heading (99.00), peduncle length (98.88) starch percent (98.61), grain yield per plant

(98.41), harvest index (98.32), 1000-grain weight (96.80), Biological yield per plant (95.22), ear length (95.30), relative water content (90.70), ear weight (83.91), Number of tillers per plant(83.22), canopy temperature (78.94), chlorophyll content (66.55), number of spikes per plant (61.71), number of spikelet per spike (46.25), lowest heritability was recorded for protein% (37.55).

In late sowing condition, high heritability was obtained for sedimentation value (99.40) followed by days to maturity (93.2) protein% (91.6) relative water content (90.61)starch content (86.8), chlorophyll content (86.60) 1000-grain weight (85.8), grain yield per plant(85.00), biological yield per plant (83.8), days to 50% heading (83.00), harvest index (77.77), plant height (75.88), peduncle length (68.51), canopy temperature (67.10) and the lowest heritability was recorded for number of spikelet per spike (10.33).

Data presented in table 4 & 5 indicate estimated data of genetic advance under normal and late sown condition. The high genetic advance as percentage of mean (at 5% selection intensity) under normal sown condition was recorded for peduncle length (38.23) followed by grain yield per plant (27.67), sedimentation value (25.75), whereas, moderate value was observed for ear length (19.14), harvest index (18.52), number of tillers per plant(17.86), ear weight (15.76), days to 50% heading (13.69), plant height (12.60), biological yield per plant (12.91), thousand grain weight (10.42), relative water content (10.18), days to maturity (8.90) number of ear per plant (10.95), chlorophyll content (10.64), canopy temperature (7.36), starch percent (4.05), protein% (5.56), number of spikelet per ear (4.78).High genetic advance as percentage of mean (at 5% selection intensity) under late sown condition, was recorded for sedimentation value (27.47) followed by peduncle length (25.27), chlorophyll content (15.92), 1000-grain weight (15.51), grain yield per plant(14.41), biological yield per plant (11.26), harvest index (10.73), protein% (13.33), relative water content (10.27) and whereas, moderate value was observed for plant height (8.99), ear weight (8.71), days to maturity (7.93), ear length (7.01), canopy temperature (6.77), days to 50% heading (6.40), number of tillers per plant(5.67), number of spikes per plant (4.83%), starch content (3.68), and lower value was observed for number of spikelet per spike (1.69).In conformity with the present investigation, high heritability coupled with high genetic advance have also been reported by Jamil (2017) [7], Kumar *et al.* (2017) [2, 11]. for plant height and days to 50% heading. Jariko *et al.* (2017) [8]. for ear length, Bhushan *et al.* (2013) [3]. and Mishra and Shukla (2013) [13] for biological yield reported similar results.

Table 1: List of genotype uses in experiment

S No	Name of genotype	S No	Name of genotype	S No	Name of genotype
1	MP 3493	11	MP 3513	21	GW 322
2	MP 3495	12	MP 3514	22	JW 3211
3	MP 3497	13	MP 3515	23	MP 3288
4	MP 3503	14	MP 3516	24	MP 3336
5	MP 3507	15	MP 3517	25	MP 3382
6	MP 3508	16	MP 3518	26	Borlog100
7	MP 3509	17	MP 3519	27	GS 7014
8	MP 3510	18	MP 3520	28	GS 7059
9	MP 3511	19	MP 3521	29	GS 10016
10	MP 3512	20	MP 3522	30	GS 10056

Table 2: Mean sums of squares for yield, its components and quality attributes in wheat for (normal sowing):

S. No.	Source of variation	d. f.	Mean Sum of Squares								
			DH	DM	PH	NTPP	NEPP	NSPE	EL	EW	PL
1	Replication	2	1.30	0.57	1.41	0.21	0.54	0.13	0.20	0.04	0.65
2	Genotype	29	64.98***	73.18***	106.17***	2.14***	1.21***	2.81*	3.50***	0.15***	32.99***
3	Error	58	0.633	0.49	0.36	0.36	0.46	1.51	0.16	0.02	0.39
4	S.E.		0.45	0.40	0.34	0.34	0.39	.0.71	0.23	0.09	0.36
5	C.D.5%		1.30	1.15	0.99	0.98	1.11	2.01	0.66	0.25	1.03
6	C.D. 1%		1.73	1.53	1.31	1.30	1.48	2.67	0.88	0.333	1.37

S. No.	Source of variation	d. f.	Mean Sum of Squares									
			BYPP	GYPP	TGW	HI	CT	CC	RWC	SD	PP	SC
1	Replication	2	2.12	0.52	0.91	0.11	5.02	69.53	5.47	0.14	1.48	0.02
2	Genotype	29	18.77***	13.56***	14.16***	41.93***	3.04***	35.68***	48.03***	97.19***	2.54***	5.13***
3	Error	58	0.90	0.22	0.45	0.70	0.64	11.96	4.46	0.05	1.59	0.07
4	S.E.		0.54	0.27	0.38	0.48	045	1.96	1.19	0.14	0.72	0.15
5	C.D.5%		1.55	0.76	1.10	1.37	1.31	5.66	3.46	0.39		0.43
6	C.D. 1%		2.06	1.02	1.46	1.82	1.74	7.54	4.59	.053		0.57

*significant at 5% **significant at 1%

DH= Days to 50% heading, **DM**= Days to maturity, **PH**= Plant height (cm), **NTPP**= Number of tillers per plant, **NEPP**= Number of ear per plant, **NSPS** = Number of spikelet per ear, **EL**= Ear length (cm), **EW**= Ear weight, **PL** = Peduncle length (cm), **BYPP** = Biological yield per plant (g), **GYPP** = Grain yield per plant(g), **TGW**= Thousand grain weight (g), **HI** = Harvest index (%), **CT** = Canopy temperature (ºC), **CC** = Chlorophyll content (SPAD Units), **RWC**= Relative water content, **SDS** = Sedimentation value (ml) **PP** = Protein (%,) **SC**= Starch (%).

Table 3: Mean sums of squares for yield, its components and quality attributes in wheat for late sowing

S. No.	Source of variation	d. f.	Mean Sum of Squares								
			DH	DM	PH	NTPP	NEPP	NSPE	EL	EW	PL
1	Replication	2	0.05	0.13	5.69	0.01	2.74	6.21	1.59	0.08	3.34
2	Genotype	29	14.32***	54.72***	72.64***	1.17***	1.34***	2.35***	0.73***	0.21***	19.09***
3	Error	58	0.90	1.29	6.97	0.63	0.90	1.75	0.15	0.10	2.54
4	S.E.		0.54	0.65	1.52	0.45	0.54	0.76	0.22	0.18	0.92
5	C.D.5%		1.55	1.85	4.31	1.29	-	-	0.64	0.53	2.60
6	C.D. 1%		2.07	2.47	5.74	1.72	-	-	0.86	0.70	3.46

S. No.	Source of variation	d. f.	Mean Sum of Squares									
			BYPP	GYPP	TGW	HI	CT	CC	RWC	SD	PP	SC
1	Replication	2	1.98	0.68	9.56	1.55	1.96	2.20	1.62	0.04	0.74	0.23
2	Genotype	29	14.10***	2.47***	23.48***	12.52***	3.80***	34.59***	42.21***	1.11***	100.72***	4.59***
3	Error	58	0.85	0.13	1.23	1.09	0.53	1.33	1.41	0.03	0.18	0.22
4	S.E.		0.53	0.21	0.64	0.60	0.42	0.66	0.68	0.10	0.25	0.27
5	C.D.5%		1.50	0.60	1.81	1.71	1.19	1.88	1.94	0.29	0.70	0.77
6	C.D. 1%		2.00	0.80	2.41	2.27	1.58	2.51	2.58	0.39	0.94	1.02

*significant at 5% **significant at 1%

DH= Days to 50% heading, **DM**= Days to maturity, **PH**= Plant height (cm), **NTPP**= Number of tillers per plant, **NEPP**= Number of ear per plant, **NSPS** = Number of spikelet per ear, **EL**= Ear length (cm), **EW**= Ear weight, **PL** = Peduncle length (cm), **BYPP** = Biological yield per plant (g), **GYPP** = Grain yield per plant(g), **TGW**= Thousand grain weight (g), **HI** = Harvest index (%), **CT** = Canopy temperature (ºC), **CC** = Chlorophyll content (SPAD Units), **RWC**= Relative water content, **SDS** = Sedimentation value (ml) **PP** = Protein (%,) **SC**= Starch (%).

Table 4: Parameters of genetic variability for yield, its components and quality attributes in wheat normal sowing

S. No.	Traits	Mean	Range		$\sigma^2 g$	GCV%	$\sigma^2 p$	PCV%	H^2 % (BS)	Genetic Advance (5%)	Genetic advanv+ce as % of mean
			Min.	Max.							
1	Days to 50% heading	69.33	61.33	77.00	21.45	6.68	21.66	6.71	99.00	9.49	13.69
2	Days to maturity	113.51	103.33	121.66	24.23	4.33	24.39	4.35	99.30	10.10	8.90
3	Plant height (cm)	96.89	87.76	108.96	35.26	6.12	35.39	6.14	99.74	12.21	12.60
4	Number of tillers per plant	8.12	6.66	10.66	0.59	9.50	0.71	10.42	83.22	1.45	17.86
5	Number of ear per plant	7.37	6.00	9.33	0.24	6.76	0.40	8.61	61.71	0.80	10.95
6	Number of spikelet per plant	19.26	17.66	20.33	0.43	3.41	0.93	5.02	46.25	0.92	4.78
7	Ear length (cm)	11.07	9.30	13.13	1.11	9.52	1.16	9.75	95.30	2.12	19.14
8	Ear weight (cm)	2.46	1.93	2.91	0.04	8.35	0.05	9.11	83.91	0.38	15.76
9	Peduncle length (cm)	17.65	11.06	22.83	10.86	18.67	10.99	18.78	98.88	6.74	38.23
10	Biological yield per plant	37.96	31.72	42.70	5.95	6.42	6.25	6.58	95.22	4.90	12.91
11	Grain yield per plant	15.56	10.87	18.79	4.44	13.54	4.52	13.87	98.41	4.30	27.67
12	1000 grain weight (g)	41.57	35.95	45.33	4.57	5.14	4.72	5.22	96.80	4.33	10.42
13	Harvest index %	40.87	34.28	46.71	13.74	9.07	13.97	9.14	98.32	7.57	18.52
14	Canopy temperature (%)	22.22	19.40	24.90	0.80	4.02	1.01	4.53	78.94	1.63	7.36
15	Chlorophyll content (SPAD 502)	44.37	34.70	58.40	7.90	6.33	11.89	7.77	66.55	4.72	10.64
16	Relative water content (%)	73.40	65.35	81.66	14.52	5.19	16.01	5.45	90.70	7.47	10.18
17	Sedimentation value (ml)	45.50	35.22	56.84	32.37	12.50	32.39	12.51	99.99	11.71	25.75
18	Protine (%)	12.80	11.54	14.15	0.31	4.40	0.84	7.19	37.55	0.71	5.56
19	Starch (%)	65.42	62.11	67.98	1.68	1.98	1.70	1.99	98.61	2.65	4.05

Table 5: Parameters of genetic variability for yield, its components and quality attributes in wheat late sowing

S. No.	Traits	Mean	Range		σ 2g	GCV%	σ 2p	PCV%	H2 % (BS)	Genetic Advance (5%)	Genetic advanv+ce as % of mean
			Min.	Max.							
1	Days to 50% heading	62.05	57.00	66.00	4.47	3.41	5.38	3.74	83.10	3.97	6.40
2	Days to maturity	105.80	99.00	116.33	17.81	3.99	19.1	4.13	93.22	8.39	7.93
3	Plant height (cm)	93.33	85.26	101.40	21.89	5.01	28.8	5.76	75.81	8.39	8.99
4	Number of tillers per plant	7.24	5.33	8.00	0.18	5.85	0.81	12.43	22.10	0.41	5.67
5	Number of ear per plant	6.14	4.00	7.33	0.14	6.26	1.05	16.70	14.00	0.29	4.83
6	Number of spikelet per plant	17.54	15.66	19.00	0.20	2.56	1.95	7.97	10.30	0.29	1.69
7	Ear length (cm)	9.55	8.76	11.20	0.19	4.59	0.35	6.19	55.51	0.67	7.01
8	Ear weight (cm)	2.29	1.82	2.67	0.03	8.33	0.14	16.39	25.52	0.20	8.71
9	Peduncle length (cm)	15.84	11.43	20.46	5.51	14.82	8.06	17.92	68.50	4.04	25.27
10	Biological yield per plant	35.20	30.47	37.96	4.41	5.97	5.27	6.52	83.80	3.96	11.26
11	Grain yield per plant	11.62	10.10	14.18	0.77	7.59	0.91	8.23	85.00	1.67	14.41
12	1000 grain weight (g)	33.48	27.64	39.72	7.41	8.13	8.64	8.78	85.81	5.19	15.51
13	Harvest index %	33.00	29.99	39.57	3.80	5.91	4.90	6.71	77.77	3.54	10.73
14	Canopy temperature (%)	26.02	23.56	28.26	1.09	4.01	1.62	4.90	67.11	1.76	6.77
15	Chlorophyll content (SPAD 502)	40.69	33.63	47.30	11.08	8.18	12.42	8.66	89.33	6.48	15.92
16	Relative water content (%)	70.39	59.55	76.41	13.60	5.24	15.01	5.50	90.60	7.23	10.27
17	Sedimentation value (ml)	43.28	30.38	54.72	33.51	13.37	33.70	13.41	99.41	11.89	27.47
18	Protine (%)	11.47	10.23	12.55	0.36	5.24	0.39	5.47	91.60	1.118	13.33
19	Starch (%)	62.97	60.35	65.41	1.45	1.92	1.68	2.06	86.81	2.31	3.68

Conclusion

Following major conclusion has been drawn from present study in which 30 genotypes were evaluated in randomized block design in normal and late sown condition to access the variability based on quantitative and qualitative characters for yield and yield attributing traits.

- The analysis of variance revealed that mean sum of squares due to genotypes was highly significantly for all the traits, indicating the presence of sufficient genetic variability in the existing material. Traits *viz.*, days to 50% flowering, days to maturity, plant height, number of effective tillers, number of ears per plant, number of spiklets per spike, ear length, ear weight, peduncle length,

number of grains per ear, thousand grain weight, grain yield per plant, biological yield per plant exhibited the value of higher magnitude for variability.

- The values of phenotypic coefficient of variation for all the traits under study were found more than genotypic coefficient of variation. The phenotypic and genotypic coefficient of variation were estimated to be high for peduncle length, grain yield per plant, sedimentation value, ear length, harvest index, ear weight, number of ear per plant, days to 50% heading, biological yield per plant, chlorophyll content, plant height, relative water content and thousand grain weight whereas, protein percent, days to maturity, canopy temperature, number of spikelet per spike and starch percent showed moderate to low (GCV) and (PCV).
- High heritability coupled with high genetic advance as percentage of mean were recorded for traits *viz.*, sedimentation value, peduncle length and grain yield per plant. Further other traits showed moderate heritability and genetic advance. This indicate substantial contribution of additive genetic variance. In late sowing condition, sedimentation value and peduncle length showed high heritability with high genetic advance and other traits showed further moderate heritability and genetic advance.

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