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GENETIC VARIABILITY IN F₅ AND F₆ GENERATIONS OF BREAD WHEAT (*Triticum Aestivum* L.) UNDER TIMELY AND LATE SOWN CONDITIONS

Satender Yadav^{1*}, Vikram Singh¹, Shikha Yashveer², Mukesh Kumar¹, Virender Singh Mor³, Anu¹

¹Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (125004), India

²Department of Molecular Biology, Biotechnology & Bioinformatics, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (125004), India

³Department of Seed Science & Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (125004), India

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KEYWORDS

Genotypic coefficient of variation

Phenotypic coefficient of variation

Timely sown

Late sown

Heritability

Wheat

ABSTRACT

The present study was conducted to assess the genetic variability in 238 F₅ and F₆ progenies derived from WH 711 / WH 542 cross for nineteen yield, its components and physiological traits. Analysis of variance showed significant differences among the genotypes for all the traits. The phenotypic coefficient of variation was found higher than their respective genotypic coefficient of variation for all the traits in both the generations indicating the least influence of the environment. Moderate to High PCV and GCV were observed for chlorophyll-b, chlorophyll-a, carotenoids, number of grains per spike, grain weight per spike, grain yield per meter, biological yield per meter, harvest index. High heritability was recorded for days to heading, chlorophyll-a, chlorophyll-b, carotenoids, number of grains per spike, grain weight per spike in both the generations. Similarly moderate to high genetic advance was observed for chlorophyll-b, seed density, grain weight per spike. Therefore these traits must be given importance during the selection for genetic improvement.

* Corresponding author

E-mail: satenderyadav.satu@gmail.com (Satender Yadav)

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1 Introduction

Wheat (*Triticum aestivum* L.) is one of the world's major cereal crops grown in temperate regions, occupying 17% of the world's cropped acreage and a staple food for 40% of the world's population (Peng et al., 2011). Worldwide, wheat contributes substantially to the human diet and food security. In addition to its principle use throughout the world in making bread, large quantities of wheat are also used in making semolina and confectionery products. Wheat was grown on 220.06 million hectares throughout the world's produced 763.18 million tons of grain with a productivity of 3.47 metric tons per hectare during the year 2018-19. India is the second largest producer of wheat in the world with the area, production and productivity of 29.55 million hectares, 101.20 million tons and 3.42 metric tons per hectare, respectively, during 2018-19. In Haryana, wheat was grown over an area of 25.10 lakh hectares, with a production of 11.65 million tons and a productivity of 4.64 metric tons per hectare during 2018-2019 (Progress Report-IIWBR, 2019). Approximately 90% of the total wheat production of India is contributed by the five states i.e., Uttar Pradesh, Punjab, Haryana, Madhya Pradesh and Rajasthan (Kumar et al., 2019). However, despite high productivity wheat faces numerous biotic (rusts, smuts, blights, powdery mildews etc.) and abiotic (drought, heat, salinity, alkalinity, excess and scarcity of nutrients etc.) stresses. Among the abiotic challenges, high temperature stress is one of the major stresses (Balla et al., 2019). Globally temperature has been increasing since the beginning of the century, and this trend is predicted to continue in the future. Mean global temperature is predicted to rise by 1-6°C by the end of the century (Anonymous, 2014). The rising concentration of greenhouse gasses is becoming a major cause of global warming. The world has been facing linear trends of increasing maximum and minimum temperatures per decades by 0.3 and 0.2°C, respectively since 1980- 2011 (Lobell & Gourdji, 2012). In India 1°C increase in daily maximum and minimum temperature are reported to reduce 2-4% of wheat yield (Gupta et al., 2016) while a net reduction of 19-28 Mt of wheat yield is projected for 3-5° C rise in temperature (Aggarwal & Singh, 2010). Reduction in yield is associated with chronically high temperatures during early grain filling as well as during the late reproductive stage. Terminal heat stress is a problem of 40% temperate wheat growing areas (Reynolds et al., 2001; Hays et al., 2007). Under high temperature, though genotype tend to increase the grain growth rate to compensate duration reduction and maintenance of grain weight but still faces yield loss. During post anthesis period, wheat optimally grows between 22-25°C temperature, beyond that, it feels the heat; causing irreversible damage. However, the intensity of light and duration of exposure will decide the quantum of yield loss under heat stress (Wahid et al., 2007).

The best strategy to overcome these losses due to heat stresses is to develop genotypes that can yield better under stress conditions. The success of a breeding program depends largely upon the amount of genetic diversity among parents and the extent to which the desired

traits are heritable which affects the generation and selection of transgressive segregants in any breeding program. The development of wheat genotypes with high yield under terminal heat stress conditions will help in attaining genetic gains. Heritability and genetic advance are important parameters which help plant breeder in determining the characters for early generation selection. Therefore keeping in mind the above points we investigated the extent of genetic variability, heritability and genetic advance for grain yield and its component traits in 238 recombinant inbred lines of wheat.

2 Materials and methods

The 238 progenies each of the F₅ and F₆ generations of wheat generated from the cross WH 711 / WH 542 [Dr. Vikram Singh, CCS HAU, Hisar (2012), Unpublished data] were evaluated for yield and its component traits under two planting conditions, timely (November 6, 2016 and November 8, 2017) and late sown (December 9, 2016 and December 8, 2017) at CCS Haryana Agricultural University, Hisar. The seed of each progeny was sown in a row of 2.5 meter length, with a spacing of 20 cm in a randomized complete block design (RBD) with two replications. All the recommended package of practice was followed to raise the crop. Data on days to maturity, plant height, number of tiller per meter, spike length, number of spikelets per spike were recorded at the time of maturity whereas observations on days to heading was recorded when 50% spikes emerged in each line. The number of grains per spike, grain weight per spike, 100-grain weight, seed density, grain length, grain breadth, grain yield per meter, biological yield per meter and harvest index were recorded after threshing. The physiological traits like canopy temperature, chlorophyll-a, chlorophyll-b, carotenoids content were measured at the time of heading. Canopy temperature (CT) measured using hand held infrared thermometer (IRT), model AG-42, Tele temp crop Fullerton. Chlorophyll a, chlorophyll b and carotenoids ratio was estimated by the method of Hiscox & Isrealstam (1979). Analysis of variance for the observations recorded on different characters was carried out as per the standard procedure of Fisher (1930). Genotypic (GCV) and phenotypic (PCV) coefficients of variation were estimated according to Burton & Devane (1953). Heritability in broad sense and Genetic advance were worked out as per the procedures of Falconer (1981) and Johnson et al. (1955), respectively. PCV and GCV classified as high (>20%), moderate (10-20%) and low (<10%). Heritability was classified as high (>80%), moderate (40-80%) and low (<40%). Genetic advance classified as high (>20%), moderate (10-20%) and low (<10%).

3 Results and Discussion

3.1 Analysis of variance

The analysis of variance as a measure of variability (Table 1 and Table 2) indicated significant differences among the genotypes for all the characters viz. days to heading, canopy temperature, chlorophyll-a,

chlorophyll-b, carotenoids, days to maturity, plant height, number of tiller per meter, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, 100-grain weight, seed density, grain length, grain breadth, grain yield per meter, biological yield per meter and harvest index under both timely and late sown condition. The enormous variability present in the RILs was an evidence of inherit differences among the parents, which is a pre-requisite for molecular mapping studies. Many earlier workers including Jin et al. (2016), Bhusal et al. (2016) and Wang et al. (2017) reported significant differences among bread wheat recombinant inbred lines. Thapa et al. (2019) reported significant variation among wheat genotypes for days to heading, canopy temperature depression (CTD), plant height (cm), grain number per spike, grain yield per plant (gm) and biological yield per plant (gm) under normal and heat stress environments.

3.2 Mean performance

The mean and range value for different traits is presented in Table 3 and Table 4. The mean value under timely sown condition was 92.08 ± 0.29 and 93.54 ± 0.32 for DH; 19.84 ± 0.32 and 19.15 ± 0.38 for CT; 1.97 ± 0.14 and 1.84 ± 0.19 for Ch-a (mg/g); 0.47 ± 0.13 and 0.46 ± 0.16 for Ch-b (mg/g); 0.68 ± 0.09 and 0.64 ± 0.13 for Cart (mg/g); 140.21 ± 0.24 and 139.88 ± 0.26 for DM; 89.47 ± 0.53 and 88.98 ± 0.63 for PH; 146.87 ± 0.66 and 142.08 ± 1.01 for NTPM; 11.45 ± 0.27 and 11.96 ± 0.28 for SL; 20.79 ± 0.27 and 20.48 ± 0.28 for NSPS; 60.59 ± 0.87 and 56.72 ± 0.99 for NGPS; 2.61 ± 0.12 and 2.51 ± 0.19 for GWPS; 3.72 ± 0.16 and 3.53 ± 0.21 for 100-GW; 1.62 ± 0.33 and 1.39 ± 0.25 for SD; 6.06 ± 0.12 and 6.33 ± 0.12 for GL; 3.13 ± 0.15 and 3.07 ± 0.15 for GB; 241.03 ± 2.22 and 232.51 ± 2.88 for GY; 619.11 ± 3.03 and 634.65 ± 3.79 for BY; and 39.10 ± 0.73 and 36.93 ± 0.96 for HI in F_5 and F_6 generations respectively. Similarly, under the late sown conditions the mean value was 71.25 ± 0.31 and 71.97 ± 0.26 for DH; 22.98 ± 0.39 and 22.91 ± 0.34 for CT; 1.74 ± 0.21 and 1.63 ± 0.20 for Ch-a (mg/g); 0.44 ± 0.13 and 0.45 ± 0.11 for Ch-b (mg/g); 0.60 ± 0.13 and 0.56 ± 0.11 for Cart (mg/g); 122.84 ± 0.10 and 122.68 ± 0.17 for DM; 82.59 ± 0.59 and 80.23 ± 0.64 for PH; 127.99 ± 0.91 and 130.14 ± 1.10 for NTPM; 10.40 ± 0.25 and 11.06 ± 0.28 for SL; 19.32 ± 0.27 and 19.73 ± 0.27 for NSPS; 51.80 ± 1.02 and 54.37 ± 1.09 for NGPS; 2.02 ± 0.31 and 2.13 ± 0.33 for GWPS; 3.07 ± 0.24 and 3.09 ± 0.28 for 100-GW; 1.34 ± 0.30 and 1.41 ± 0.24 for SD; 5.80 ± 0.12 and 6.13 ± 0.12 for GL; 2.80 ± 0.19 and 2.69 ± 0.12 for GB; 168.89 ± 3.45 and 184.75 ± 3.62 for GY; 518.51 ± 4.37 and 553.75 ± 4.60 for BY; and 32.78 ± 1.10 and 33.50 ± 1.09 for HI in F_5 and F_6 generations respectively. The variation in the expression of agronomic traits and grain yield were varied due to the genetic nature and diversity of different genotypes and the diversity of the environments as well (Ferede et al., 2020). Significant differences for agronomic and yield related traits in bread wheat were reported by Kifle et al. (2016), Mekuria et al. (2018) and Upasna et al. (2019).

3.3 Genetic parameters

3.3.1 Phenotypic and genotypic coefficient of variation

Information on the nature and magnitude of genetic variability is of immense significance for initiating any breeding programme. Further the presence of considerable variability in the base material ensures better chances of evolving desired plant types. The variability is estimated through various statistics such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance which are useful in designing an effective selection strategy aimed to improve a particular population for a specific trait. The results indicated that phenotypic coefficient of variation was slightly higher than their respective genotypic coefficient of variation for all the characters in both F_5 and F_6 generations (Table 3 and Table 4). This indicates the least influence of the environment on the studied traits. The findings are similar to the results of Kaushik et al. (2013), Shankarrao et al. (2010) and Anu et al. (2019). The PCV under timely sown condition ranged from 2.08% for DM to 30.31% for Ch-b in F_5 generation and from 1.98% for DM to 25.50% for Ch-b in F_6 generation while under late sown conditions it ranged from 1.95% for DM to 27.19% for Ch-b in F_5 generation and from 1.90% for DM to 28.48% for SD in F_6 generation. The GCV under timely sown condition varied from 1.85 for DM to 28.36% for Ch-b in F_5 generation and from 1.77 for DM to 23.66 for Ch-b in F_6 generation. Under late sown condition it ranged from 1.72% for DM to 25.31 for Ch-b in F_5 generation and from 1.75% for DM to 26.30 for SD in F_6 generation. Under timely sown conditions, Ch-a, Cart, NGPS, GWPS, GY, BY, HI, Ch-b and SD showed moderate to high PCV and GCV while under late sown conditions, Ch-a, NGPS, 100-GW, BY, HI, Ch-b, GWPS, SD and GY showed moderate to high PCV and GCV under both F_5 and F_6 generation indicated high variability among the populations for these traits. High PCV with moderate GCV was reported for number of tiller per plant, number of grains per spike and grain yield per plant by Patil & Koujalagi (2018). Thapa et al., (2019) observed high GCV and PCV for canopy temperature depression, biological yield per plant, and grain yield per plant and tiller number per plant. Moderate value of PCV and GCV were reported by Yadawad et al. (2015) and Arya et al., (2017) for grain yield per plant and by Rathwa et al. (2018) for number of productive tillers per plant, grain yield per plant and harvest index. Mansouri et al. (2018) reported low GCV and PCV for plant height, canopy temperature and days to heading.

3.3.2 Heritability and genetic advance

The genetic parameter heritability determines the extent of genetic control of a given trait and its transmission to progeny and hence has bearing on the selection efficiency of trait concerned. Johanson et al. (1955) advocated that for selection to be effective, heritability

Table 3 Genetic parameters in the F₂ generation of cross WH711 x WH542 under timely sown (TS) and late sown (LS) conditions during the year 2016-17

Traits	Phenotypic Parameters						Genetic Parameters									
	WH711		WH542		Mean± SE(m)		Range		GCV (%)		PCV (%)		h ² (bs) (%)		Genetic advance as % of mean (5%)	
	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS
DH	94.00	72.00	89.00	71.00	92.08±0.29	71.25±0.31	88-96	67-78	4.22	2.71	4.43	3.02	90	80	8.26	5.02
CT (°C)	19.80	25.80	20.60	24.50	19.84±0.32	22.98±0.39	17.20-22.90	19.10-26.20	4.52	5.63	5.23	6.16	75	83	8.06	10.60
Ch-a (mg/g)	1.93	1.54	1.96	1.60	1.97±0.14	1.74±0.21	1.41-2.37	1.18-2.29	10.53	14.15	11.41	15.28	85	85	20.03	27.00
Ch-b (mg/g)	0.55	0.47	0.45	0.37	0.47±0.13	0.44±0.13	0.26-0.69	0.26-0.59	28.36	25.31	30.31	27.19	87	86	54.66	48.53
Cart (mg/g)	0.68	0.51	0.64	0.50	0.68±0.09	0.60±0.13	0.48-0.83	0.34-0.78	10.16	15.97	11.27	17.41	81	84	18.88	30.19
DM	146.00	123.00	143.00	121.00	140.21±0.24	122.84±0.10	136-145	121-124	1.85	1.72	2.08	1.95	78	78	3.38	3.14
PH (cm)	83.00	76.40	98.00	77.67	89.47±0.53	82.59±0.59	80.83-99.83	68.00-90.90	5.99	7.62	6.35	8.25	89	85	11.66	14.49
NTPM	145.00	122.00	150.00	125.00	146.87±0.66	127.99±0.91	122-159	108-144	5.25	6.30	6.47	8.00	66	62	8.78	10.23
SL (cm)	11.00	10.50	10.50	9.50	11.45±0.27	10.40±0.25	8.70-13.47	8.43-12.57	7.85	6.66	8.36	7.61	88	77	15.20	12.03
NSPS	21.00	19.00	21.00	19.00	20.79±0.27	19.32±0.27	17-23	17-21	5.29	6.26	5.89	7.17	81	76	9.80	11.25
NGPS	55.00	48.00	65.00	50.00	60.59±0.87	51.80±1.02	42.80-69.60	32.60-61.80	10.53	12.81	11.21	14.20	88	81	20.40	23.81
GWPS (g)	2.57	1.95	2.45	1.66	2.61±0.12	2.02±0.31	2.00-2.98	1.07-2.91	10.62	22.97	11.61	24.43	84	88	20.03	44.47
100-GW (g)	4.50	4.06	3.86	3.32	3.72±0.16	3.07±0.24	3.13-4.34	2.16-3.94	7.76	12.05	8.41	13.72	85	77	14.74	21.80
SD (g/cc)	1.29	1.18	1.13	1.08	1.62±0.33	1.34±0.30	0.94-2.87	0.68-2.61	22.91	22.96	25.92	26.20	78	76	41.70	41.46
GL (mm)	6.00	5.92	6.04	5.98	6.06±0.12	5.80±0.12	5.24-6.75	4.98-6.49	3.95	4.41	4.72	5.14	70	73	6.81	7.78
GB (mm)	3.23	3.03	3.02	2.75	3.13±0.15	2.80±0.19	2.45-3.66	1.93-3.49	7.74	10.26	8.34	11.59	86	78	14.81	18.69
GY (g)	225.00	190.64	205.69	168.56	241.03±2.22	168.89±3.45	144.27-326.48	102.34-265.31	12.21	23.11	14.57	26.68	70	75	21.07	41.25
BY (g)	560.25	525.79	554.36	505.79	619.11±3.03	518.51±4.37	456.28-820.00	315.42-689.76	11.43	15.38	13.77	19.56	68	63	19.54	25.10
HI (%)	40.16	36.26	37.10	33.33	39.10±0.73	32.78±1.10	23.12-45.07	20.17-40.99	9.76	16.71	11.31	19.14	74	76	17.34	30.05

DH: Days to heading, **CT:** Canopy temperature, **Ch a:** chlorophyll-a, **Ch b:** chlorophyll-b, **Cart:** carotenoids, **DM:** Days to maturity, **PH:** Plant height, **NTPM:** Number of tiller per meter, **SL:** Spike length, **NSPS:** Number of spikelets per spike, **NGPS:** Number of grains per spike, **GWPS:** Grain weight per spike, **100-GW:** 100-grain weight, **SD:** seed density, **GL:** Grain length, **GB:** Grain breadth, **GY:** Grain yield per meter, **BY:** Biological yield per meter, **HI:** Harvest index.

Table 4 Genetic parameters in the F₆ generation of cross WH711 x WH542 under timely sown (TS) and late sown (LS) conditions during the year 2017-18

Traits	Phenotypic Parameters										Genetic Parameters									
	WH711		WH542		Mean± SE(m)				Range		GCV (%)		PCV (%)		h ² (bs) (%)		Genetic advance as % of mean (5%)			
	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS		
DH	95.00	71.00	90.00	70.00	93.54±0.32	71.97±0.26	85-97	70-77	1.81	4.39	2.01	90	81	8.18	3.37					
CT (°C)	20.20	21.40	21.30	23.60	19.15±0.38	22.91±0.34	17.30-21.90	19.20-25.90	5.72	5.03	5.63	72	79	9.97	9.26					
Ch-a (mg/g)	1.80	1.60	1.83	1.65	1.84±0.19	1.63±0.20	1.17-2.30	1.07-2.26	13.18	15.66	14.62	16.92	81	85	24.47	29.85				
Ch-b (mg/g)	0.51	0.44	0.41	0.34	0.46±0.16	0.45±0.11	0.20-0.69	0.26-0.57	23.66	23.18	25.50	24.72	86	88	45.23	44.80				
Cart (mg/g)	0.74	0.52	0.61	0.48	0.64±0.13	0.56±0.11	0.38-0.79	0.36-0.76	15.35	14.57	16.40	15.85	88	84	29.59	27.58				
DM	144.00	122.00	142.00	120.00	139.88±0.26	122.68±0.17	135-146	120-125	1.77	1.75	1.98	1.90	80	85	3.25	3.32				
PH (cm)	81.50	77.00	96.43	80.37	88.98±0.63	80.23±0.64	72.83-99.90	65.03-90.97	7.36	6.76	8.24	7.51	79	81	13.54	12.53				
NTPM	142.00	125.00	155.00	128.00	142.08±1.01	130.14±1.10	110-160	107-150	7.08	9.53	8.47	11.50	69	69	12.18	16.35				
SL (cm)	11.00	10.50	10.50	9.50	11.96±0.28	11.06±0.28	9.67-13.93	8.57-13.57	8.13	9.71	8.85	11.11	84	76	15.39	17.48				
NSPS	21.00	19.00	21.00	19.00	20.48±0.28	19.73±0.27	17-23	17-23	5.70	6.38	6.24	7.07	83	81	10.73	11.86				
NGPS	53.00	46.00	64.00	48.00	56.72±0.99	54.37±1.09	40.00-67.80	30.20-68.80	12.93	15.16	14.03	16.64	85	83	24.53	28.44				
GWPS (g)	2.47	1.84	2.40	1.76	2.51±0.19	2.13±0.33	1.80-2.98	1.13-3.23	13.49	24.16	14.43	26.10	87	86	25.99	46.06				
100-GW (g)	4.48	4.00	3.89	3.40	3.53±0.21	3.09±0.28	2.51-4.40	2.14-4.29	11.15	14.93	12.36	17.51	81	73	20.71	26.21				
SD (g/cc)	1.27	1.15	1.13	1.10	1.39±0.25	1.41±0.24	0.81-2.37	0.76-3.00	18.15	26.30	21.01	28.48	75	85	32.31	50.05				
GL (mm)	6.04	5.95	6.08	6.00	6.33±0.12	6.13±0.12	5.28-6.95	5.42-6.82	4.44	4.17	5.12	4.65	75	80	7.94	7.71				
GB (mm)	3.27	3.05	3.08	2.78	3.07±0.15	2.69±0.12	2.29-3.67	2.13-3.20	7.72	6.15	8.57	7.03	81	76	14.31	11.07				
GY (g)	230.46	195.67	215.34	172.85	232.51±2.88	184.75±3.62	136.85-335.89	102.58-290.31	16.91	24.53	18.93	28.24	79	75	31.12	43.89				
BY (g)	568.46	518.24	555.54	510.78	634.65±3.79	553.75±4.60	412.34-798.25	300.51-765.18	13.19	15.97	15.07	19.62	77	66	23.78	26.78				
HI (%)	40.54	37.76	38.76	33.84	36.93±0.96	33.50±1.09	21.24-43.35	20.01-43.72	15.74	16.69	18.08	18.83	76	79	28.23	30.47				

CT: Canopy temperature, **Ch a:** chlorophyll-a, **Ch b:** chlorophyll-b, **Cart:** carotenoids, **DM:** Days to maturity, **PH:** Plant height, **NTPM:** Number of tiller per meter, **SL:** Spike length, **NSPS:** Number of spikelets per spike, **NGPS:** Number of grains per spike, **GWPS:** Grain weight per spike, **100-GW:** 100-grain weight, **SD:** seed density, **GL:** Grain length, **GB:** Grain breadth, **Gy:** Grain yield per meter, **BY:** Biological yield per meter, **HI:** Harvest index.

and genetic advance should be considered together. Heritability ranged from 66% for NTPM to 90% for DH under timely sown condition and from 62% for NTPM to 88% for GWPS under late sown condition in F₅ generation. In F₆ generation it ranged from 69% for NTPM to 90% for DH under timely sown condition and from 66% for BY to 88% Ch-b under late sown condition. Heritability was observed high for DH, Ch-a, Ch-b, Cart, NGPS and GWPS and moderate for NTPM, GY, BY and HI under timely and late sown condition as well as over the generations. High heritability is conditioned due to additive gene effects arisen from homozygous lines while heterozygous segregating population reflects low heritability marred by environment. Genetic advance as percent of mean was high for Ch-a, Ch-b, NGPS, GY, SD, GWPS, moderate for PH and SL and low for DH, CT, DM and GL under both timely and late sown condition as well as over the generations. It varied from 3.38% for DM to 54.66% for Ch-b under timely sown and from 3.14 for DM to 48.53% for Ch-b under late sown condition in F₅ generation. In F₆ generation, it ranged from 3.25% for DM to 45.23% for Ch-b and from 3.3.2% for DM to 50.05% for SD under timely and late sown condition respectively. High heritability coupled with high genetic advance was observed for Ch-a, Ch-b, NGPS and GWPS indicated that additive gene action was transmitted from the parents to the progeny to control their performance and least influence of environments on the expression of these traits. These traits can easily improve by selection in early generations. The additive gene effects are consequences of homozygous nature of advanced generations. Moderate heritability coupled with low genetic advance was observed for DM and GL over the environments reflecting the non-additive gene action. High heritability coupled with high genetic advance for Grain yield, 1000 kernels weight and Grain number/main spike under timely (control) and late (stress) conditions has been reported by various works (Kumar et al., 2014). High heritability with moderate genetic advance was also observed for these traits by Farzamipour et al. (2013) and Choudhary et al. (2015). High heritability with low genetic advance was reported for days to maturity (Hari Kesh et al., 2017). Moderate heritability coupled with high genetic advance as percent of mean was reported by Eid (2009) for number of spike per plant and by Islam et al. (2017) for yield per plant and biological yield.

Conflicts of interest

All authors declare there is no conflict of interest among them.

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