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Research Article

Genetic Variability and Trait Association Analysis in Yield and Yield Components in Bread Wheat (*Triticum aestivum* L.) Genotypes under Rainfed Condition

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ABSTRACT

One hundred bread wheat (Triticum aestivum L.) were evaluated for genetic variability and yield performance under rainfed condition in two replication using alpha-lattice design. Substantial variations were reported among genotypes with ANOVA for all the fourteen studied traits. Low to moderate range of GCV (1.7-17.1%) and low to high PCV (2.3-23.4%), GAM (3.5-32.6%) and heritability (42.9-79.2%) were reported. At genotypic level GY showed positive and highly significant correlation with DTH, DTA, DTM, NOT, SL, BM, HI, TKW and TNG at genotypic level and with DTM, BM, HI, TKW and TNG at phenotypic level. TKW and TNG showed highest positive and direct effect on GY in path analysis. Genotypes HI1531, HI1581 and C306 were showed highest yield.

Keywords: *Wheat, Rainfed, Genetic variability, Correlation, Path analysis.*

INTRODUCTION

Global food security for the coming generations is a prime issue across the continents due to rapidly diminishing natural resources and climate change (Behnassi et al., 2018). Wheat (*Triticum aestivum* L.) is one of the most important pillars of global food security. It provides 41% of total calories and 50% of total proteins consumed from cereals globally (Shiferaw et al., 2013). Across the globe, it cultivated on nearly 220 million hectares area with an average 670 million tons of annual production (Ramadas et al., 2019). In near future, wheat demand is expected to be raise by 60%. At present climatic anomalies are the major threat for crop productions. Climate change has significantly affected the global food security by means of affecting the crop production across the world through many ways among them water stress in one (Shan et al., 2020). Therefore, development of climate resilient crop varieties has become a major objective for plant breeders. Wheat crop is highly sensitive to water availability (Choudhury & Kumar, 1980). Water stress at any point of wheat plant lifecycle significantly reduces grain yield and quality.

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In past few years due to climate change incidences of water stress have substantially increased throughout the world with a great impact on wheat production. Therefore, development of drought tolerant wheat varieties is a major goal for both national and international wheat breeding programs.

Pre-breeding which includes evaluation and development of genetic resources, development of selection indices, and estimation of genetic variability is the base of a successful sustainable breeding program. With this reason, here in this study we have studied a set of one hundred bread wheat (*Triticum aestivum* L.) genotypes for their yield performance, genetic variability and trait association under rainfed conditions.

MATERIALS AND METHODS

Filed experiment: The field experiment was conducted during *Rabi* 2018-19 at experimental farms of Section of Wheat and Barely Breeding, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University. A total of 100 bread wheat (*Triticum aestivum* L.) genotypes were field planted in alpha lattice experimental design with two replications in first week of November-2018. Each genotype was sown using dibbling method with following planting specification: seed depth: 10 cm, plant to plant spacing: 10 cm, row to row spacing: 20 cm, plot to plot spacing: 100 cm, block to block spacing: 150 cm. No irrigation was given throughout the life cycle rest agronomic practices were carried out as per recommended package of practices.

Data collection: The following agronomic data were collected on per plant basis: 1) days to heading (DTH) were measured as the number of days until 75% of the plants had fully emerged spikes, 2) days to flowering (DTA) were measured as the number of days until 75% of the plants had fully emerged anthers, 3) days to maturity (DTM) were measured as the number of days until 75% of the plants had reached senescence, 4) grain filling duration (GFD) period between DTA and DTM, 5) productive tiller number (NOT) was measured as the number of tillers that had managed to set seed, 6) plant height (PH) was measured as the height from base of the plant to the point where the spike emerged, 7) peduncle length (PL) was measured from first internode to base of the spike. 8) spike length (SL) was measured from the base of the spike to the tip of the spike, 9) spikelets per spike (SPS) were measured by counting the number of spikelets per spike, 10) biomass (BM) was measured as mass of all above-ground plant parts, 11) grain yield (GY) was measured after harvesting using an electronic balance, 12) harvest index (HI) percentage ration between GY and BM, 13) thousand kernel weight (TKW) was measured by randomly sampling 1000 kernels and weighing them, and 14) Total number of grains per plant (TNG) were measured by counting total number of grains harvested.

Data analysis:

Analysis of variance for each trait was calculated using restricted maximum likelihood (ReML) method in R environment with following model.

$$Y_{ijk} = \mu + Rep_i + Block_j \times Rep_i + Gen_k + \mathcal{E}_{ijk}$$

Broad sense heritability (H^2) was calculated as

$$H^2 = \frac{\sigma_g^2}{\sigma_g^2 + \frac{\sigma_e^2}{r}} \times 100$$

where ‘σ_g^2’, ‘σ_e^2’ and ‘r’ are genetic variance, residual variance and number of replications, respectively.

genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was calculated as a percentage ratio between under root of corresponding variance ($\sigma^2_{g\ or\ p}$) and grand mean ($\bar{X}$).

Genetic advance and genetic advance over grand mean were calculated for each environment, management and across the environment as per (Johnson et al., 1955).

a. Genetic advance (GA)

$$\mathrm{GA} = \mathrm{k.h^2.\sigma^2}$$

b. Genetic advance over mean (GAM)

$$\mathrm{GAM} = \frac{\mathrm{GA}}{\bar{\mathrm{X}}}$$

Where: k is standardized selection differential at 5% selection intensity (2.06), h^2 is broad sense heritability for the trait, $\bar{X}$ is population mean for the trait.

Furthermore, categorization of GCV and PCV was done as suggested by Sivasubramanin and Menon (1973) and for heritability and GAM% categorization suggested by Johnson et al. (1955).

Category	GCV and PCV	Heritability	GAM
Low	<10%	<30%	<10%
Moderate	11-20%	31-60%	11-20%
High	>20%	60>	>20%

Phenotypic and genotypic correlation coefficients of all the characters were worked-out as per Al-Jibouri et al. (1958) and path coefficient analysis was carried-out as per the method suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

In present investigation, ANOVA advocated the existence of substantial genetic variability at significance level $p>0.01$ in the study material for all the fourteen studied traits (Table 1). For some traits such as GY, BM and TNG we reported difference among replications. This expected difference among replications was due to uncontrollable errors which generated due to uneven distribution of water stress in the open fields however, effects of these errors on present study were negligible or in acceptable range. The coefficient of variation (CV%) ranged between 1.4% and 18.7% (Table 2). High values (>10%) of CV for the traits NOT, PH, BM, GY, HI and TNG show that these traits are under the influence of environment thus selection based on these traits can be misleading. With this reason traits with low CV could be used with more reliability. Similar results were reported by (Shamuyarira et al., 2019). We reported a wide range for all the studied traits (Table 2). Among the evaluated genotypes, HI1531, HI1581 and C306 were the highest yielder. These genotypes are identified drought tolerant varieties thus the present investigation also supported previous claims and recommendations to use these genotypes for limited water conditions.

Estimation of genetic variance (Table 2) revealed that for all the traits PCV was greater from the corresponding GCV. For DTH, DTA and DTM both GCV, PCV and GAM were low. PH, SPS and TKW were recorded with low GCV and moderate PCV and GAM. Both GCV and PCV were reported moderate for GFD, PL, SL, GY and TNG whereas, for NOT, BM and HI GCV and PCV were moderate and high, respectively. Furthermore, moderate GAM was reported for GFD, PH, SPS, and TKW and high GAM was reported for NOT, PL, SL, BM, GY, HI and TNG. We reported high broad sense heritability (H^2) for all the traits excluding PH, BM and TNG which had moderate level of H^2. Results from GCV and PCV illustrate that variability in the present study material is largely influenced with environmental factors rather than genetic factors. Furthermore, traits with high heritability and high GAM indicates the high responsiveness to selection and presence of additive effects whereas, for traits with high heritability to moderate heritability and moderate to low GAM indicates the presence of non-additive effects thus multiple selection cycle will be needed for these traits. Our results are in agreement with many previous studies however some contradiction arises due to difference in plant material and climatic conditions during studies (Shamuyarira et al., 2019; Mathew et al., 2018; Mwadzingeni et al., 2016; Jatoi et al., 2012).

Relatedness between studied traits in the present study material was estimated at both genotypic and phenotypic levels. At genotypic level GY showed positive and highly significant correlation with DTH, DTA, DTM, NOT, SL, BM, HI, TKW and TNG at $p>0.01$ and with PH and SPS at $p>0.05$. In contrast to this at phenotypic GY showed significantly positive association with DTM, BM, HI, TKW and TNG. Detailed results on correlation studies are presented in Table 3. Correlation studies are affirmative with Qaseem et al. (2019), Malav et al. (2017) and Mia et al. (2017). Furthermore, to partition and estimate the effect of individual trait on GY path coefficient analysis was carried out (Table 4). Results from the path analysis revealed that in the scenario of present investigation, DTH, DTM, TKW and TNG had a higher magnitude of direct effect on GY in positive direction whereas DTA and GFD had it in negative direction. Rest of the traits showed a very low magnitude of direct effect on GY among which PL, SL and BM had positive effect and NOT, PH, SPS and HI had negative effect. Since, TKW and TNG had largest direct on GY we pursued the indirect effect of other traits on GY *via* these traits. DTH, DTA, SPS and SL showed negative indirect effect of low magnitudes on GY *via* TKW whereas rest of the traits imposed positive indirect effects. TKW increases GY by means of weight. Indirect effect of various traits on GY *via* TKW can be understand by physiological basis of growth and development of wheat kernel. GFD increases with early DTH/DTA and delayed maturity. A longer GFD allows increased accumulation of assimilates in developing grain which lead to increase in the kennel weight. Higher number of NOT and PL are associated with increased green area of plant which allow more assimilation of photosynthates. Additionally, PL stores water soluble carbohydrates which works as reservoirs under water stressed conditions. High HI further indicates the transformation of BM into GY. Unlike TKW, TNG contributes in GY by means of numbers. In present investigation all the traits excluding GFD and PL showed positive indirect effect on GY *via* TNG. These traits increase TNG by maintain pollen fertility under water stress conditions. Early DTH and DTA are associated with escape mechanism. Increased NOT improves the canopy cover and green area which improve assimilation and carbon mobilization necessary to maintain the pollen fertility. Longer SL assures a greater number of spikelets thus a greater number of grains. These results are in agreement with previous studies of Malav et al. (2017), Gelalcha & Hanchinal (2013), Khan et al. (2005) and many others.

Table 1: Mean squares analysis of variance involving fourteen phenotypic traits of hundred wheat genotypes evaluated in two replications under rainfed conditions

Source	Mean Sum of Squares													
	DTH	DTA	DTM	GFD	NOT	PH	PL	SL	SPS	BM	GY	HI	TKW	TNG
Rep	67.28	74.30	26.65	199.80	337.73	2349.99	5.55	3.20	2.00	0.38	488.50	5932.96	0.60	318140.47
Block	30.43	32.62	18.84	16.96	3.35	321.76	33.23	1.10	5.38	39.14	4.62	73.20	20.22	2974.45
Genotype	23.74	25.20	10.54	21.01	4.46	246.46	27.90	3.26	7.35	62.99	5.71	76.10	27.33	3047.03
Error	8.31	10.90	3.10	8.68	1.81	160.77	7.35	0.94	2.34	25.93	1.82	19.82	6.93	1509.06

Table 2: Genetic parameters for yield and associated traits in hundred wheat genotypes under rainfed condition

Statistic	**DTH**	**DTA**	**DTM**	**GFD**	**NOT**	**PH**	**PL**	**SL**	**SPS**	**BM**	**GY**	**HI**	**TKW**	**TNG**
	81.79	89.76	117.91	28.11	7.85	94.52	30.19	10.86	19.75	29.06	10.17	35.96	39.43	259.06
Minimum	70.50	78.00	112.00	22.00	4.95	73.95	22.03	7.95	15.00	18.94	5.88	19.92	31.26	169.84
Maximum	90.50	98.00	123.50	37.50	14.13	127.35	44.06	17.85	24.00	48.33	14.93	61.76	48.72	360.78
σg^2	11.06	10.25	4.45	8.18	1.81	57.99	13.11	1.27	2.93	16.60	2.28	34.08	12.31	956.78
σp^2	18.73	20.27	7.41	16.06	3.36	211.82	19.98	2.13	5.28	46.23	4.17	53.59	19.08	2492.67
σe^2	7.67	10.02	2.95	7.87	1.55	153.83	6.87	0.86	2.35	29.64	1.89	19.51	6.76	1535.89
H^2 (%)	74.26	67.15	75.09	67.52	70.03	42.99	79.25	74.63	71.35	52.83	70.65	77.75	78.46	55.47
GCV (%)	4.07	3.57	1.79	10.18	17.15	8.06	11.99	10.36	8.66	14.02	14.84	16.23	8.90	11.94
PCV (%)	5.29	5.02	2.31	14.26	23.37	15.40	14.80	13.43	11.63	23.40	20.08	20.36	11.08	19.27
GA	6.62	6.23	4.21	5.57	2.65	12.89	7.30	2.24	3.38	7.40	2.97	11.73	7.06	57.05
GAM (5%)	8.09	6.94	3.57	19.83	33.71	13.64	24.17	20.64	17.10	25.47	29.23	32.60	17.90	22.02
LSD (5%)	4.83	5.27	3.18	4.60	2.08	16.45	4.85	1.60	2.59	7.90	2.31	8.02	4.59	58.20
CV (%)	3.39	3.53	1.46	9.98	15.87	13.12	8.68	8.54	7.76	18.74	13.53	12.28	6.60	15.13

Table 3: Genotypic (below diagonal) and phenotypic (above diagonal) correlation coefficients among fourteen characters in hundred genotypes of bread wheat under rainfed condition

	DTH	**DTA**	**DTM**	**GFD**	**NOT**	**PH**	**PL**	**SL**	**SPS**	**BM**	**GY**	**HI**	**TKW**	**TNG**
DTH	**1**	0.974**	0.449**	-0.756**	-0.143*	0.111	-0.023	-0.041	-0.042	0.052	0.054	0.004	-0.103	0.119
DTA	0.997**	**1**	0.476**	-0.763**	-0.147*	0.115	0.007	-0.045	-0.048	0.057	0.018	-0.037	-0.138	0.105
DTM	0.521**	0.554**	**1**	0.190**	-0.044	0.327**	0.325**	-0.01	0.078	0.276**	0.196**	-0.139*	0.082	0.150*
GFD	-0.787**	-0.770**	0.112	**1**	0.144*	0.103	0.241**	0.033	0.111	0.129	0.121	-0.051	0.225**	-0.015
NOT	-0.344**	-0.402**	-0.187**	0.319**	**1**	-0.037	-0.001	0.005	-0.058	-0.042	0.103	0.157*	0.087	0.058
PH	0.298**	0.400**	0.840**	0.194**	0.089	**1**	0.474**	-0.025	0.054	0.305**	0.065	-0.257**	0.105	-0.002
PL	-0.013	0.013	0.507**	0.354**	0.003	1.130**	**1**	-0.057	0.032	0.276**	0.071	-0.225**	0.114	0.001
SL	-0.012	-0.007	0.051	0.05	0.103	0.012	-0.155*	**1**	0.293**	0.022	0.12	0.073	-0.025	0.140*
SPS	0.215**	0.215**	0.240**	-0.02	-0.127	0.03	0.01	0.419**	**1**	0.073	0.059	-0.07	-0.079	0.11
BM	0.240**	0.313**	0.703**	0.202**	0.033	0.967**	0.583**	0.127	0.260**	**1**	0.548**	-0.557**	0.1	0.513**
GY	0.212**	0.202**	0.450**	0.134	0.251**	0.171*	0.098	0.223**	0.174*	0.340**	**1**	0.341**	0.350**	0.837**
HI	-0.076	-0.142*	-0.186**	0.009	0.218**	-0.577**	-0.448**	0.076	-0.109	-0.501**	0.651**	**1**	0.231**	0.224**
TKW	-0.073	-0.106	0.238**	0.290**	0.194**	0.172*	0.178*	-0.033	-0.195**	0.214**	0.609**	0.403**	**1**	-0.204**
TNG	0.308**	0.317**	0.391**	-0.031	0.163*	0.047	-0.026	0.302**	0.409**	0.269**	0.807**	0.519**	0.019	**1**

*, ** Significant at 5% and 1% levels, respectively

Table 4: Genotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on grain yield in 50 genotypes of bread wheat

	DTH	**DTA**	**DTM**	**GFD**	**NOT**	**PH**	**PL**	**SL**	**SPS**	**BM**	**HI**	**TKW**	**TNG**	**GY#**
DTH	**0.260**	-0.559	0.092	0.218	0.005	-0.023	-0.001	0.000	-0.017	0.010	0.005	-0.044	0.267	0.212**
DTA	0.259	**-0.561**	0.098	0.213	0.006	-0.031	0.001	0.000	-0.017	0.013	0.009	-0.063	0.275	0.202**
DTM	0.136	-0.311	**0.177**	-0.031	0.003	-0.066	0.039	0.002	-0.019	0.028	0.011	0.142	0.339	0.450**
GFD	-0.205	0.432	0.020	**-0.277**	-0.005	-0.015	0.027	0.002	0.002	0.008	-0.001	0.173	-0.027	0.134
NOT	-0.090	0.225	-0.033	-0.088	**-0.015**	-0.007	0.000	0.003	0.010	0.001	-0.013	0.115	0.142	0.251**
PH	0.078	-0.224	0.149	-0.054	-0.001	**-0.078**	0.087	0.000	-0.002	0.039	0.035	0.102	0.041	0.171*
PL	-0.004	-0.007	0.090	-0.098	0.000	-0.089	**0.077**	-0.005	-0.001	0.023	0.028	0.106	-0.023	0.098
SL	-0.003	0.004	0.009	-0.014	-0.002	-0.001	-0.012	**0.031**	-0.033	0.005	-0.005	-0.019	0.262	0.223**
SPS	0.056	-0.120	0.043	0.006	0.002	-0.002	0.001	0.013	**-0.078**	0.010	0.007	-0.116	0.354	0.174*
BM	0.063	-0.175	0.124	-0.056	-0.001	-0.076	0.045	0.004	-0.020	**0.040**	0.031	0.127	0.234	0.340**
HI	-0.020	0.080	-0.033	-0.003	-0.003	0.045	-0.035	0.002	0.009	-0.020	**-0.062**	0.240	0.450	0.341**
TKW	-0.019	0.060	0.042	-0.080	-0.003	-0.013	0.014	-0.001	0.015	0.009	-0.025	**0.595**	0.017	0.350**
TNG	0.080	-0.178	0.069	0.009	-0.002	-0.004	-0.002	0.010	-0.032	0.011	-0.032	0.011	**0.867**	0.837**

Residual are -0.00424, *, ** Significant at 5 % and 1% levels, respectively, # Genetic correlation

Table 5: Trait wise mean performance of bread wheat genotypes used in the present investigation

Genotype	DTH	DTA	DTM	GFD	NOT	PH	PL	SL	SPS	BM	GY	HI	TKW	TNG
HI1531	82.00	89.50	121.00	31.50	6.20	103.65	30.84	9.60	19.00	40.39	14.93	38.54	41.18	360.78
HI1581	85.00	92.00	122.50	30.50	6.60	97.95	33.24	11.49	20.00	38.76	14.25	36.73	45.32	314.18
C306	85.50	93.00	122.00	29.00	10.60	124.80	44.06	9.90	21.00	42.88	14.01	33.22	45.44	308.40
WH1138	84.50	92.50	117.50	25.00	8.95	87.45	28.84	10.50	17.00	32.86	13.29	41.20	43.38	306.36
WH1129	86.50	94.00	119.00	25.00	8.90	87.75	29.24	11.63	21.00	38.34	13.20	33.58	39.88	335.94
HD2009	86.50	94.50	120.00	25.50	7.50	92.10	32.04	12.74	21.00	36.62	12.93	35.09	40.09	323.57
HD3128	80.00	87.00	118.00	31.00	8.35	82.65	27.63	10.80	20.00	21.22	12.60	61.76	43.86	291.82
WH1124	84.00	91.00	117.50	26.50	7.45	90.75	29.24	10.50	17.00	34.11	12.48	37.73	44.07	283.01
BRW3723	85.50	94.00	121.50	27.50	7.00	115.65	32.04	17.85	23.00	35.55	12.40	35.18	43.78	283.16
HD2987	81.00	89.50	119.00	29.50	8.25	73.95	31.24	10.50	19.00	27.70	12.39	44.64	40.49	303.39
HI1580	81.00	88.00	112.50	24.50	6.40	94.80	31.64	12.27	21.00	30.46	12.36	39.88	40.63	307.91
WH1080	83.00	90.50	116.50	26.00	7.66	96.45	28.44	11.48	19.00	25.69	12.18	49.19	47.89	253.98
WH1100	79.50	87.50	117.00	29.50	6.80	88.05	30.04	10.28	17.00	32.86	12.18	38.69	40.10	306.73
WH542	81.00	89.50	122.00	32.50	6.55	100.50	33.64	11.40	23.00	32.73	12.17	37.71	45.66	269.27
DBW107	71.50	80.00	116.50	36.50	8.45	87.60	29.24	11.10	24.00	25.91	12.09	46.56	37.86	321.42
FLW-11	75.50	84.00	117.50	33.50	8.30	88.05	28.84	9.90	21.00	32.42	12.00	38.42	38.90	307.22
DBW17	85.00	91.50	114.00	22.50	5.40	79.05	22.03	10.13	21.00	28.88	11.99	41.26	36.44	330.03
FLW3	84.50	92.00	119.00	27.00	9.85	87.60	26.83	11.25	21.00	30.64	11.90	38.29	37.90	313.78
Dharwad Dry	85.00	94.00	122.50	28.50	7.15	108.75	34.44	12.98	21.00	30.92	11.88	38.04	36.54	319.69
Agralocal	81.50	90.50	121.50	31.00	10.65	122.55	28.44	10.88	18.00	48.33	11.82	24.59	36.28	326.48
Hindi62	85.50	94.00	122.00	28.00	7.55	112.05	30.84	9.75	19.00	42.24	11.82	27.98	42.24	280.49
GW2002-18	82.50	90.00	120.00	30.00	7.70	101.55	31.64	11.33	20.00	32.82	11.79	37.48	38.52	310.75
HD3127	74.00	81.50	116.50	35.00	9.25	89.85	29.24	12.45	20.00	26.04	11.76	45.56	37.86	309.56
HI1500	79.50	88.00	119.00	31.00	12.56	124.20	35.24	10.50	21.00	37.98	11.76	31.75	42.89	273.83
WL3526	82.00	90.00	117.00	27.00	7.00	91.80	29.24	13.04	21.00	40.76	11.55	28.97	37.32	309.67
WBM1587	90.50	98.00	123.50	25.50	6.35	99.90	36.45	9.53	23.00	32.15	11.52	35.99	40.15	287.09
HD2997	85.50	93.50	118.00	25.00	8.35	93.15	26.03	11.40	21.00	27.37	11.34	41.21	43.76	258.44
Bacanora88	82.00	90.50	114.50	24.00	9.05	81.00	28.84	10.05	21.00	26.92	11.28	41.80	34.04	331.45
FLW29	87.00	95.00	119.00	24.00	4.95	87.90	28.04	11.40	22.00	38.50	11.24	29.18	32.52	347.99
GW173	75.00	82.50	115.00	32.50	9.45	77.25	29.64	13.73	17.00	29.01	11.13	38.72	40.06	280.55
HD3132	78.00	86.00	117.50	31.50	5.95	92.70	24.83	11.03	22.00	29.80	11.13	37.04	44.31	252.88
WH1164	78.50	86.00	112.00	26.00	10.51	93.45	26.43	11.33	21.00	27.90	11.04	40.42	38.89	284.38
HD3071	76.00	83.50	120.50	37.00	9.57	119.85	43.25	9.53	19.00	26.92	11.01	40.90	48.11	228.60
HD4730	85.50	93.00	121.00	28.00	7.55	84.00	28.04	7.95	20.00	27.97	10.98	38.24	48.72	227.30
Chirya-3	84.00	91.50	116.00	25.50	7.65	87.15	22.43	9.45	18.00	24.85	10.95	43.47	43.45	252.30
HD3146	76.00	83.00	118.00	35.00	8.70	81.90	26.43	10.95	21.00	27.81	10.91	39.75	41.21	263.01
WH1157	77.00	84.50	114.00	29.50	10.34	85.05	24.83	10.35	19.00	24.57	10.89	43.52	40.63	268.73
HD3055	80.50	89.00	120.50	31.50	6.45	93.15	29.64	10.95	18.00	28.32	10.88	39.21	37.69	288.43
HD3059	81.50	89.00	121.00	32.00	14.13	93.45	27.63	10.95	21.00	26.22	10.86	40.46	38.75	279.52
D134	79.00	87.00	119.00	32.00	8.45	83.55	29.24	8.70	16.00	28.61	10.70	36.75	45.94	231.70
DBW46	83.00	91.00	120.50	29.50	5.95	115.20	36.05	12.90	21.00	28.82	10.68	37.05	43.82	245.52
HD30	89.50	97.50	122.50	25.00	8.80	93.30	30.84	10.50	19.00	30.65	10.62	34.38	40.58	263.77
AKW2862-1	75.00	82.50	116.00	33.50	7.45	100.35	34.04	10.80	20.00	30.68	10.58	34.47	45.59	229.77
HD3086	85.00	93.00	120.50	27.50	6.64	88.35	29.24	10.95	17.00	23.12	10.56	45.96	39.94	264.51
DPW621-50	86.00	94.50	121.50	27.00	8.70	90.45	26.03	11.45	23.00	26.63	10.32	38.24	32.75	318.89
GL6	85.00	93.00	119.50	26.50	9.00	117.15	38.05	9.00	17.00	27.30	10.32	37.57	38.20	274.51
HI1563	81.00	88.50	116.00	27.50	9.10	96.00	29.24	11.70	18.00	26.50	10.32	38.41	39.92	260.04
WH1105	83.50	92.50	117.00	24.50	6.90	80.70	24.43	10.35	22.00	24.56	10.32	42.02	40.42	259.56
HD3045	83.00	91.50	120.00	28.50	7.90	105.75	39.65	9.15	18.00	34.83	10.26	30.33	44.50	230.63
HD3139	78.00	85.50	115.50	30.00	6.45	90.60	29.64	10.65	22.00	23.74	10.23	42.48	41.24	250.67
GL11	81.00	89.50	119.50	30.00	6.75	125.25	40.05	9.45	20.00	35.83	10.14	28.64	38.82	261.21
GW366	82.00	90.00	115.50	25.50	5.95	94.50	28.84	9.90	19.00	25.06	10.14	42.93	38.75	261.32
DBW98	79.00	87.00	116.50	29.50	8.90	86.70	30.84	10.43	20.00	29.62	10.02	33.68	38.50	261.82
DBW155	85.00	93.00	115.50	22.50	8.10	82.50	23.63	10.65	18.00	24.22	9.96	41.04	37.66	263.82
DBW129	85.00	93.50	117.00	23.50	7.55	101.85	29.24	11.78	24.00	34.19	9.93	29.04	40.87	243.11
WH1126	81.00	88.00	119.50	27.75	7.55	94.95	27.63	11.40	17.00	26.99	9.93	39.69	42.51	234.38
WH1061	82.50	91.00	117.00	26.00	8.00	98.10	28.04	11.61	20.00	25.75	9.90	40.22	41.11	240.83
WH423	79.50	88.50	117.00	28.50	10.15	108.60	32.84	10.05	16.00	36.19	9.89	27.47	44.65	220.62
FKW1	82.50	90.50	116.50	26.00	6.90	83.70	27.23	9.83	22.00	29.08	9.64	33.63	39.28	245.82
CBW38	85.00	92.50	118.00	25.50	7.90	88.20	26.43	13.35	20.00	27.30	9.60	35.25	33.81	284.92
DL788-2	79.00	87.00	114.50	27.50	11.55	76.05	32.44	9.75	15.00	23.40	9.60	42.97	42.00	232.46
GW455	70.50	78.00	115.50	37.50	7.55	91.35	29.24	12.53	20.00	30.25	9.60	32.92	40.06	242.11
WH1154	85.00	94.00	118.00	24.00	6.05	104.85	30.44	10.17	17.00	23.47	9.59	42.20	40.05	238.49
WH1132	85.00	93.50	118.50	25.00	8.40	93.45	31.64	10.88	18.00	24.82	9.42	37.32	38.81	239.89
AKAW3717	85.50	94.00	122.50	28.50	6.35	106.80	34.84	9.50	18.00	33.25	9.39	28.44	35.37	265.47
Halna	77.50	86.50	115.00	28.50	7.10	87.45	41.25	10.65	22.00	28.66	9.18	31.96	31.26	293.00
WH730	84.50	92.50	116.00	23.50	7.50	105.45	27.63	11.78	21.00	20.51	9.09	44.30	39.46	230.19
HD3016	81.00	89.00	116.50	27.50	9.55	92.40	31.64	10.73	19.00	22.77	9.08	40.68	44.32	205.23
WH1156	86.00	93.00	119.00	26.00	7.85	104.85	31.24	11.03	22.00	24.76	9.06	35.86	31.99	282.31
AKAW4627	76.00	83.50	115.00	31.50	8.35	92.25	25.63	9.75	22.00	35.30	8.94	25.75	36.30	248.95
Birsa Gehun	81.50	90.50	114.50	24.00	9.00	94.95	30.04	10.73	20.00	29.19	8.94	33.23	32.75	272.99
GW322	84.00	91.00	114.50	23.50	6.40	88.05	28.04	10.95	18.00	20.75	8.94	42.68	40.14	220.52
HD3118	81.50	89.00	115.00	26.00	8.25	100.80	28.44	12.00	16.00	27.99	8.91	31.11	39.21	227.62
HI1544	77.50	85.50	116.50	31.00	8.85	89.40	30.04	11.63	20.00	25.75	8.90	35.27	36.55	244.01
DBW16	84.50	93.00	119.00	26.00	6.30	90.00	23.23	9.60	16.00	21.03	8.88	41.93	39.28	227.92
Bageshwarlocal	86.00	94.50	119.50	25.00	5.95	114.00	36.05	10.13	18.00	30.89	8.85	28.53	36.57	243.21
HD3043	83.00	95.20	122.00	26.80	6.75	97.05	30.04	11.70	19.00	27.50	8.82	31.34	34.80	253.15
DBW128	85.50	93.50	121.00	27.50	6.75	92.25	31.24	11.78	22.00	31.59	8.79	27.73	33.56	261.65
DBW51	77.50	85.50	116.00	30.50	6.15	101.25	32.04	10.35	19.00	34.16	8.66	24.97	40.10	218.36
WH1046	78.50	87.50	113.00	25.50	5.98	81.90	27.63	9.98	18.00	32.25	8.61	28.13	40.06	215.08
WH1142	83.00	90.50	117.00	26.50	11.00	91.47	27.23	12.30	23.00	23.26	8.49	35.83	34.74	240.59
DL1266-5	79.50	87.50	118.00	30.50	6.95	77.85	27.63	13.30	22.00	19.93	8.48	41.95	40.36	211.10

Genotype	DTH	DTA	DTM	GFD	NOT	PH	PL	SL	SPS	BM	GY	HI	TKW	TNG
DBW39	87.50	96.00	118.00	22.00	7.05	82.95	24.03	10.05	20.00	23.88	8.46	36.91	32.71	262.55
HI1579	89.00	94.50	119.00	24.50	8.65	94.05	26.03	10.17	21.00	22.29	8.46	37.88	40.56	208.23
GW496	76.00	84.00	118.50	34.50	7.10	81.90	31.24	10.43	18.00	26.99	8.37	30.93	38.83	214.98
BWL9022	85.50	93.50	117.50	24.00	6.15	93.15	35.24	11.10	23.00	30.46	8.34	26.93	38.29	218.44
GW451	78.00	85.00	113.00	28.00	8.85	77.55	26.83	9.68	17.00	20.77	8.34	40.37	37.54	227.16
WL711	84.50	92.50	116.50	24.00	6.65	85.05	28.04	9.68	19.00	30.11	8.28	28.01	40.79	203.40
HD1981	77.50	86.00	117.00	31.00	10.50	84.30	28.44	11.18	18.00	28.70	7.95	29.15	39.24	202.21
DBW31	77.00	84.50	119.50	35.00	7.95	90.00	30.84	12.30	23.00	28.55	7.86	27.47	45.30	175.23
GW273	81.50	88.50	118.00	29.50	9.15	92.70	33.64	11.85	22.00	32.02	7.68	24.05	38.03	203.04
DBW110	81.00	89.00	113.50	24.50	9.00	88.20	29.24	11.03	17.00	19.71	7.59	38.24	39.08	195.13
WH1097	85.50	93.00	118.50	25.50	6.15	99.45	30.44	10.73	18.00	33.66	7.59	23.83	33.16	230.53
AKW1071	85.00	93.00	118.00	25.00	7.55	96.60	28.84	10.20	19.00	18.94	7.56	40.24	35.78	211.03
WBM1591	82.00	89.50	121.00	31.50	6.20	116.37	36.29	8.55	19.00	26.89	7.56	28.53	32.90	229.50
GW391	83.50	92.50	119.00	26.50	5.60	89.55	27.23	9.87	21.00	29.37	7.32	24.74	42.41	175.34
FLW5	83.50	92.25	119.00	26.00	6.15	82.35	29.64	10.07	19.00	27.08	7.10	26.28	31.88	223.93
WH595	76.50	83.50	114.00	30.50	7.55	79.80	26.83	10.58	18.00	22.20	7.02	31.10	32.65	210.15
GL27	77.00	85.50	118.00	32.50	5.85	127.35	37.65	9.75	20.00	32.74	6.33	19.92	37.60	169.84
WH147	78.00	86.50	114.00	27.50	6.85	94.50	28.04	9.90	21.00	21.47	5.88	27.37	32.60	181.24

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