International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(4): 95-99

https://www.mathsjournal.com
Received: 07-05-2023
Accepted: 13-06-2023

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Evaluation of genetic parameters and association for the enhancement of yield improving characterization in wheat breeding lines

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Abstract

A total number of five hundred and twenty-two, advanced breeding lines of wheat were estimated of genetic variability, heritability and genetic advance under the normal environmental condition at the BISA farm of Jabalpur, (India) in 2018-2019 & 2019-2020 rabi season. Analysis of observed data were highly significant. GCV and PCV were highest for a number of productive tiller per plant followed by biomass per plot, peduncle length, number of grain per spike and lowest to days to 50% flowering and days to 50% heading. Heritability estimates were high for days to 50% heading and days to 50% flowering followed by biomass/plot, grain yield/plot and lowest for spike length and number of spikelets/spike in case of both environments. The estimates of genetic advance (GA) were highest for biomass/plot followed by grain yield/plot, number of grain/spikes, days to 50% flowering, days to 50% heading and lowest for spike length, number of productive tillers and peduncle length under both environments. grain yield gave a positive correlation with the number of productive tillers, spike length, number of spikelets /spike, number of grains/spike and biomass. While it give negative correlation with days to 50% heading, days to 50% flowering and days to maturity. This study suggests that the presence of adequate genetic variability, heritability and genetic advance and its relationship among yield for contributing traits under a normal environment is suitable for breeding programs and crop improvement.

Several methods for hybrid development in wheat have been deployed like heterosis, male sterility, use of CHA's, use of molecular mapping, use of biparental mapping, use of MAS, etc. Unfortunately, still attention should be paid for seed setting in wheat to enhance the genetic variance and heritability. In this regard, we therefore investigated 522 advanced breeding lines for anther extrusion and its associated traits in wheat, to explore the wheat genome with the help of anther extrusion through genome wide association analysis and to apply reaction norms GXE models to predict anther extrusion in multi-environment setting with the aim of getting maximum genetic gain in the hybrid wheat breeding program.

Keywords: Biomass, improvement, heritability, variability, GCV, PCV etc

Introduction

In India, wheat is grown on approx. 30 million hectares million with an annual production of about 107.59 million tonnes (59th All India wheat & barley research workers' virtual meet, 24-25 August, 2020). The maximum production is recorded in India was 108.75 million tonnes during 2020-2021 (Directorate of Economics and Statistics, 2020-2021). It is known for its remarkable adoption to a wide range of environment and constitutes major portion of cereal. The importance of wheat is derived from the properties of gluten. World population has been predicted to rise by 9 billion in 2050, leading to increase in the demand for wheat up to 60%. To meet this requirement, annual wheat yield must increase with a rate of 1.6% from the current level of 1%. Wheat is an annual plant and is widely cultivated for its seed, a cereal grain (Shewry *et al.*, 2009) [16]. Bread wheat is an allohexaploid with chromosome number 2n=6x=42 comprising three genetically related genomes A, B & D.

It belongs to the family Poaceae (Gramineae) and became domesticated in the Fertile Crescent and Mediterranean regions (Feldman and Levy, 2015) [18]. Wheat is divided into three major groups *viz.* diploid; 2n=2x=14, tetraploids; 2n=4x=28 and hexaploids; 2n=6x=42. The tetraploid and hexaploid are derived from mutation and hybridization resulting in a wide range of adaptability in the modern wheat. Among all those bread wheat accounts 95 percent, 4 percent *durum* wheat and 1 percent *dicoccum* wheat, respectively (Gupta, 2004) [17]. In India it is a second major staple crop after rice and plays a key role in food and nutritional security. It provides 21% of calories, 20% of protein for more than 4.5 billion people in 94 countries. Wheat is a very rich source of carbohydrate and having a protein content of about 13%, which is relatively high compared to other cereal grains (Shewry *et al.*, 2015) [13].
Wheat is a temperate crop and is cultivated over a wide range of climatic conditions in India. It can be cultivated from sea level to high as 3300 meter above the sea level. Being a Rabi season crop, the best favorable conditions for wheat cultivation are, cool, moist weather during the major portion of the growing period followed by dry, and warm weather to enable the grain to ripen properly. The optimum temperature range for ideal wheat is 20-25 °C.

Material and Methods
Advanced wheat breeding lines obtained from wheat breeding program will be planted at locations BISA Jabalpur in two seasons (Rabi 2018-19 & 2019-20). A total of 522 wheat lines were evaluated in both the seasons in the locations. The experiment was conducted in a randomized block design with two replication.
Observations on morphological data are recorded during both the years by following wheat descriptors (1985). The data for morphological traits are recorded on ten representative plants from each plot.

Observations to be recorded
Following traits were recorded from the advanced breeding lines of wheat:

1. Days to 50% heading
2. Days to 50% flowering
3. Days to maturity
4. Peduncle length(cm)
5. Plant height (cm)
6. Number of productive tillers.
7. Number of spikelet's per spike
8. Spike length(cm)
9. Number of grains per spike
10. Non extruded anthers per spike
11. Anther extrusion%
12. Visual score of anther extrusion
13. Biomass(g)
14. Grain yield (g)
15. Thousand seed weight(g)

Heritability
Within the environment and across the environments the heritability has been calculated by using following formula:
Within the environment

$H^2= σ_g^2/ σ_g^2+ σ_e^2/n \text{ reps}$

Across the environments

$H^2= σ_g^2+ σ_g^2/n \text{ env}+ σ_e^2/(n \text{ reps x n env})$
Where,
$σ_g^2$- Genotypic variance
$σ_e^2$- Environment variance
$σ_{ge}^2$- genotype by environment interaction variance
n env- number of environments
n reps- number of replication

Result and Discussion
Correlation Coefficient Analysis
Estimates of correlation coefficients were determined to show the degree of association between yield and its components and among yield components. The genetic (rG) and phenotypic correlation (rP) between two characters, X and Y, were estimated according to Akhtar *et al.* (2011) [1].

Table 1: Analysis of variance of fifteen traits in wheat lines for Rabi 2019, 2020 and for Jabalpur, Locations

S No.	Characters	Mean Sum of Squares					
		Replications		Treatments		Error	
Degree of Freedom		JBL19	JBL20	JBL19	JBL20	JBL19	JBL20
		1	1	521	521	521	521
1	Days to 50% heading	975.17	207.11	50.77**	25.81**	2.76	3.24
2	Days to 50% flowering	973.24	207.11	51.29**	44.28**	2.58	3.24
3	Days to maturity	979.04	207.11	60.15**	23.16**	2.42	3.24
4	Peduncle length (cm)	11.76	94.93	12.68**	14.02**	2.98	3.18
5	Plant height (cm)	20.36	45.5	65.59**	60.39**	9.7	12.71
6	Number of productive tillers	15.69	78.35	4.65**	3.08**	0.99	0.83
7	Spike length (cm)	0.01	2.41	2.38**	4.34**	0.62	1.1
8	Number of spikelets per spike	0.16	29	6.61**	5.38**	1.66	1.45
9	Number of grains per spike	8.46	0.02	80.99**	72.87**	17.92	20.18
10	Biomass (g)	378329.38	732831.03	66581.84**	37719.88**	7298.89	6414.72
11	Grain yield (g)	39946.27	85177.11	394.49**	10642.18**	63.68	1291.86
12	Thousand seed weight (g)	378.44	309.31	35.87**	33.63**	2.25	2.95

*&** Significant at *P*<0.05 and *P*<0.01, respectively

Table 2: Correlation coefficient analysis among the different traits of Wheat lines evaluated in the field conditions in Rabi-2019 at Jabalpur, Madhya Pradesh, India

Traits	DH50	DF50	DM	PL	PH	NPT	SL	NSPS	NGPS	NEA	AE%	Visual_AE	BM	GYPP	TSW
DH50	1														
DF50	0.96**	1													
DM	0.18**	0.17**	1												
PL	-0.01	-0.03	-0.02	1											
PH	0.05	0.05	0.15**	0.27**	1										
NPT	0.06	0.04	0.01	-0.01	0.04	1									
SL	-0.05	-0.05	0.02	0.07	0.24**	0.04	1								
NSPS	-0.02	-0.03	0.03	-0.05	0.27**	0.01	0.23**	1							
NGPS	-0.05	-0.03	0.05	-0.04	0.18**	-0.02	0.21**	0.58**	1						
NEA	-0.11**	-0.10*	0.01	0.05	0.03	-0.05	-0.02	-0.01	-0.01	1					
AE%	0.12**	0.10*	-0.01	-0.05	-0.03	0.05	0.02	0.01	0.01	-0.98**	1				
Visual AE	-0.09*	-0.07	-0.01	0.05	0.05	-0.04	-0.01	0.01	-0.01	0.97**	-0.96**	1			
BM	0.06	0.07	0.13**	0.04	0.49**	0.03	0.18**	0.32**	0.32**	0.06	-0.06	0.08	1		
GYPP	-0.11**	-0.11**	-0.11**	0.08	-0.03	0.13**	0.10*	0.13**	0.17**	0.07	-0.08	0.05	0.11**	1	
TSW	0.02	0.01	-0.09	0.01	-0.01	0.06	0.02	0.07	0.02	-0.04	0.04	-0.03	-0.04	0.01	1

*&** Significant at $p<0.05$ and $p<0.01$, respectively

DH50: Days to 50% heading, DF50: Days to 50% flowering, DM: Days to maturity, PL: Peduncle length, PH: Plant height, NPT: No. of productive tillers, SL: Spike length, NSPS: No. of spikelet's per spike, NGPS: No. of grains per spike, NEA: No. of no-extruded anthers per spike, AE%: Anther extrusion percentage, Visual AE: Visual score of anther extrusion, BM: Biomass, GYPP: Grain yield, TSW: Thousand seed weight.

Table 3: Correlation Coefficient Analysis among the different traits evaluated in Wheat lines evaluated in the field conditions in Rabi-2020 at Jabalpur, Madhya Pradesh, India

Traits	DH50	DF50	DM	PL	PH	NPT	SL	NSPS	NGPS	NEA	AE%	Visual_AE	BM	GYPP	TSW
DH50	1														
DF50	0.73**	1													
DM	0.18**	0.18**	1												
PL	-0.10*	-0.14**	0.03	1											
PH	0.01	-0.06	-0.18**	0.16**	1										
NPT	0.02	0.03	-0.03	-0.01	0.04	1									
SL	-0.10*	0.01	-0.10*	-0.10*	0.10*	-0.02	1								
NSPS	0.07	0.11**	-0.02	-0.09*	0.09*	0.01	0.24**	1							
NGPS	0.06	0.06	0.07	0.06	0.06	0.01	0.04	0.09*	1						
NEA	0.34**	0.34**	0.06	-0.07	-0.02	-0.03	-0.05	-0.01	-0.01	1					
AE%	-0.35**	-0.33**	-0.06	0.08	0.01	0.02	0.06	0.01	0.01	-0.99**	1				
Visual_AE	0.38**	0.35**	0.02	-0.11**	-0.01	0.01	-0.07	0.01	-0.01	0.68**	-0.67**	1			
BM	-0.04	-0.12**	-0.05	0.18**	0.31**	0.05	0.12**	0.16**	0.07	-0.07	0.08	-0.03	1		
GYPP	-0.11**	-0.13**	-0.04	0.17**	0.30**	0.07	0.17**	0.15**	0.11**	-0.13**	0.13**	-0.10*	0.67**	1	
TSW	-0.15**	-0.16**	-0.04	0.08	0.10*	0.06	-0.04	-0.08	-0.06	-0.05	0.04	-0.09*	0.05	0.08	1

*&** Significant at $p<0.05$ and $p<0.01$, respectively

DH50: Days to 50% heading, DF50: Days to 50% flowering, DM: Days to maturity, PL: Peduncle length, PH: Plant height, NPT: No. of productive tillers, SL: Spike length, NSPS: No. of spikelet's per spike, NGPS: No. of grains per spike, NEA: No. of no-extruded anthers per spike, AE%: Anther extrusion percentage, Visual AE: Visual score of anther extrusion, BM: Biomass, GYPP: Grain yield, TSW: Thousand seed weight.

Blup and correlation analysis across two years at Jabalpur

1. All the traits under study showed significant variation (** Significant at $p<0.01$), among all the lines in two years 2019 and 2020 at Jabalpur.
2. In all the floral traits under investigation, the genotypic variance was found significant (** Significant at $p<0.01$) in days to 50% heading and days to 50% flowering. It was recorded 24.00 in 2019 and 11.28 in 2020 for days to 50% heading. The heritability found highest for this trait and was calculated 94.56% and 87.44% in 2019 and 2020 respectively. The genotypic variance showed a significant difference among all the lines for days to 50% flowering. It was calculated 24.35 and 20.51 in 2019 and 2020 respectively. For days to 50% flowering, the heritability found maximum in both the years and was calculated 94.96 and 92.67% in 2019 and 2020 respectively.
3. The correlation showed that grain yield gave a positive correlation with the number of productive tillers (0.13; $p < 0.01$), spike length (0.10; $p<0.05$), number of spikelets per spike (0.13; $p<0.01$), number of grains per spike (0.17; $p<0.01$) and biomass (0.11; $p<0.01$) in 2019. Whereas, grain yield is positively correlated with peduncle length (0.17; $p<0.01$), plant height (0.30; $p<0.01$), spike length (0.17; $p<0.01$), no. of spikelets per spike (0.15. $p<0.01$), no. of grains per spike (0.11; $p<0.01$), AE% (0.13; $p<0.01$) and biomass (0.67; p; 0.01) in 2020
4. There was a strong correlation between days to 50% flowering and days to 50% heading in both the years at Jabalpur identified and was recorded 0.96; $p < 0.01$ and 0.73; $p < 0.01$ in 2019 and 2020 respectively. It was also recorded that days to maturity showed a positive correlation between days to 50% heading and days to 50% flowering. The values identified were 0.18; $p<0.01$ and 0.17; $p<0.01$ for days to 50% heading and days to 50% flowering respectively in 2019. Similarly, the values identified for 0.18; $p<0.01$ and 0.18; $p<0.01$ for days to 50% heading and days to 50% flowering respectively in 2020.

Conclusion

In this study, we presented and discussed the results from ANOVA for 15 traits in wheat lines across two years (2019 & 2020) at location (Jabalpur) that exhibited significant differences among themselves *viz*. days to 50% heading, days to 50% flowering, days to maturity, peduncle length (cm), plant height (cm), no. of productive tillers, spike length(cm), number of spikelets per spike, number of grain per spike, non extruded anthers per spike, anther extrusion%, visual score of anther extrusion, biomass (g),grain yield (g) and thousand seed weight. We expect these results to be applicable and contributive in the domestication and improvement efforts of other novel annual and perennial plant species. Selected breeding lines from this study from phenotypical evaluation can be validated again and can be utilized in future wheat breeding programmes.

Competing interests

Authors have declared that no competing interests exist.

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