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Relationship among the yield and its yield contributing traits in spring wheat (*Triticum aestivum* L.)

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Abstract
Advanced wheat breeding lines were tested in RBD design at Jabalpur, india in 2018/19 rabi season,. The major purpose was to study the association among yield and yield contributing characters and recognizing the traits which have the most direct and indirect impact on grain yield. Analysis of variance revealed that there was a significant difference among the advanced wheat breeding lines for all the characters deliberated. Grain yield had positive correlation with number of productive tillers per plant, spike length, number of spikelets per spike, number of kernels per spike and biomass yield per plot at both phenotypic and genotypic levels. Among these characters biological yield and number of kernels per spike had positive correlation with grain yield in the process of selection much attention should be given to them as these characters are helpful for indirect selection.

Keywords: Correlation, anther, extrusion, biomass

Introduction
Wheat is a highly self-pollinated annual plant which plays a major role with the few crop species being extensively grown-up as staple food sources in the world Mollasadeghi *et al*., 2012 [7]. It was one of the first cereals to be domesticated, and is thought to have originated in the 'Fertile Crescent' Dubcovsky *et al*., 2007 [4]. Globally, wheat is the chief source of cereal and vegetable protein in human food, having higher protein content than either maize (corn) or rice, the other major cereals. In terms of total production tonnages used for food, it is currently ahead of rice and maize as the main human food crop, after allowing for maize's more widespread use in animal feeds Mollasadeghi *et al*., 2012 [7] Grain yield in wheat is a difficult character and is the product of several attributing factors touching yield directly or indirectly. These factors manipulate grain production both directly and indirectly and the breeder is naturally apprehensive in investigating the extent and type of association of such traits Zafarnaderi *et al*., 2013 [11]. Towards a clear understanding of the type of plant traits, correlation. Phenotypic and genotypic correlations within varieties are of value to indicate the degree to which various characters are associated with economic productivity Mudasir *et al*., 2010 [8]. Correlation coefficient is an necessary statistical method, which can assist wheat breeders in selection for higher yields. Some of the researchers showed the positive correlation between grain yield and yield element traits in wheat such as spikes number per plant and grains number per spike Kashif *et al*., 2004 [5] straw yield and 1000 kernel weight Akbar *et al*., 1995 [1] with biological yield and the harvest index Ali *et al*., 2012 [2]. The grain yield and its yield components are affected very much by the genotype and the environment of wheat. For that reason, the new cultivars are being formed by breeding, the breeders study the relationships between the yield and its components. To increase the yield, study of direct and indirect effects of yield components provide the basis for its successful breeding plan and hence the trouble of yield increase can be more efficiently tackled because of the performance of yield components traits and selection for strongly related characters Chowdhry *et al*. 2000 [3]. Although the correlation estimates are useful in determining the components of complex trait such as yield, they do not provide an accurate picture of the relative significance of direct and indirect effect of each of the module characteristics of this trait. So far, little information is generated about character relationship between the yield and yield contributing parameters in genotypes of wheat.

Therefore, the purpose of this study was to assess the association among yield and yield contributing quantitative traits and recognize those traits that have the most direct and indirect effects on grain yield.

Materials and Methods

Detail of the study area

The experiment was conducted at BISA (Jabalpur), India in 2018/19 rabi cropping season. The maximum and minimum temperatures of the area are 24.72°C and 8.76°C, respectively, whereas the mean annual rainfall is 1080.4mm. The major soil types are alluvial (Vertisol) and clay loam with pH of 6.5.

Experimental materials

A total of 522 advanced wheat (*Triticum aestivum* L.) breeding lines. The accessions were obtained kindly from CIMMYT, Mexico. The lines were selected based on their agronomic performances and suitability to the growing conditions.

Experimental design and trial execution

The experiment was carried out in Randomized Block Design with 2 replication. The lines were grown under uniform rainfed conditions. The plot size was two rows of 1.0m length with 0.22m row spacing i.e. 0.44mx0.5m =0.22m2. Planting was done by hand drilling on Nov 23, 2012. Seed rate was 150kg/ha (45g/plot). Recommended fertilizer rate of 100/100kg/ha N/P2 O5 in the forms of Urea and DAP was applied to each plot in the shallow furrow depths and mixed with soil at the same time during sowing. For data collection, 10 plants were tagged randomly for data collection from each plot.

Table 1: List of the quantitative traits studied under the trial under

Sr. No.	Trait	Description
1	Days to 50% heading	The genotypes were closely observed from the date of seed sown, to the initiation of heading in 50% of the plants in a line, were recorded for each treatment, in each replication.
2	Days to 50% flowering	The genotypes were closely observed from the date of seed sown, to the initiation of a flower blooming in 50% of the plants in a line, were recorded for each treatment, in each replication.
3	Days to maturity	The number of days taken from the time of sowing of seed to the time of physiological maturity, for each entry, in each replication.
4	Peduncle Length (cm)	Length taken from the region between the spike base and flag leaf
5	Plant height (cm)	Plant height is measured in terms of centimeter at the time of maturity from the ground level to the top of the spike excluding awns
6	Number of productive Tillers	The total number of productive tillers were counted in each tagged plant for each entry in each replication and averaged
7	Spike length (cm)	The length of the spike was recorded by measuring from the base to tip of the spike.
8	Number of spikelets per spike	The average number of spikelets per spike from five typical spikes selected from a growing line
9	Number of grains per spike	The number of seeds per spike was counted from five randomly selected spikes of the five randomly selected plants from each line in each replication and averaged.
10	Non extruded anthers per spike	Number of non extruded anthers are calculated and averaged in all the plants.
11	Anther extrusion %	Anther extrusion was taken when 50 percent of the spikes had anthers showing and were shedding pollen, which is anthesis date. AE = Total extruded anthers/total number of anthers*100
12	Visual score of anther extrusion	Lines are visually rated using a scale from 0 to 9 with one indicating that little or only the tip of the anther is visible and nine indicating high number of anthers fully presented outside the floret
13	Biomass (g)	Biomass of ten randomly selected plants was recorded in gram separately and averaged for each replication before threshing
14	Grain yield (g)	The grain yield per plot was measured in grams using sensitive balance after moisture of the seed is adjusted to 12.5%.
15	Thousand seed weight (g)	1000 seeds from the bulk stock of each test entries were taken and weight at 10-12 percent moisture content 'wet weight' as according to ISTA rule in triplicate and average 1000 seed weight worked out in gram.

Results and Discussion

Analysis of variance (ANOVA):- Mean squares of the 15 characters from analysis of variance (ANOVA) are presented in (Table 2).

Table 2: Analysis of variance of fifteen traits in wheat lines for Rabi 2019, for Jabalpur, Location

S. No.	Characters	Replication	Mean sum of squares treatment	Error
		JBL19	JBL19	JBL19
	Degree of Freedom	1	1	1
1	Days to 50% heading	975.17	50.77**	2.76
2	Days to 50% flowering	973.24	51.29**	2.58
3	Days to maturity	979.04	60.15**	2.42
4	Peduncle length (cm)	11.76	12.68**	2.98
5	Plant height (cm)	20.36	65.59**	9.70
6	Number of productive tillers	15.69	4.65**	0.99
7	Spike length (cm)	0.01	2.38**	0.62
8	Number of spikelets per spike	0.16	6.61**	1.66
9	Number of grains per spike	8.46	80.99**	17.92
10	Number of Non extruded anthers per spike	75.10	309.98**	12.42
11	Anther extrusion %	1157.11	840.52**	42.55

12	Visual score of anther extrusion	15.69	5.47**	0.58
13	Biomass (g)	378329.38	66581.84**	7298.89
14	Grain yield (g)	39946.27	394.49**	63.68
15	Thousand seed weight (g)	378.44	35.87**	2.25

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

Correlation Coefficient Analysis

In the present investigation, the correlation coefficient analysis showed that there is a significant correlation between yield and its attributing traits in all the locations and environments. The detailed study on correlation coefficients at Jabalpur *(Rabi- 2018-19)* are indicated in Table 3. In *Rabi-2018-19* at Jabalpur, grain yield gave positive correlation with 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*). While it give negative correlation with days to 50% heading *(-0.11; p<0.01*), days to 50% flowering *(-0.11; p<0.01*) and days to maturity *(-0.11; p<0.01*). It has been observed that there is no correlation found between grain yield and number of no-extruded anthers per spike, anther extrusion % and visual score on anther extrusion. The results revealed that no. of non-extruded anthers per spike gave negative correlation with days to 50% heading (*-0.11; p<0.01*) and days to 50% flowering (*-0.10; p<0.05*). Whereas, AE% showed positive correlation with days to 50% heading (*0.12; p<0.01*) and days to 50% flowering (*0.10; p<0.05*) and gave highest, negative correlation with no. of extruded anthers per spike (*-0.98; p<0.01*). Visual score on AE showed highest and positive correlation with no. of non extruded anthers per spike (*0.97; p<0.01*) and it is negatively correlated with AE%(*-0.96; p<0.01*) and days to 50% heading (*-0.09; p<0.05*).

The trait showed positive and negative non-significant phenotypic correlation with all the rest characters. Majumder *et al*., 2008 [6] found similar results. On the opposing, Khokhar *et al*., (2010) [9] observed thousand kernels weight had highly significant and negative associations with days to 75% maturity. Biomass yield showed positive and significant correlation with days to heading and plant height and non-significant association with the rest traits at phenotypic level irrespective of direction. The findings of Mohammad *et al*. 2005 [10] contradicted these significant and positive associations of biomass yield with days to heading.

Table 3: 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.

Conclusions

Grain yield had positive correlation with number of productive tillers per plant, spike length, number of spikelets per spike, number of kernels per spike and biomass yield per plot. While it provide negative correlation with days to 50% heading, days to 50% flowering and days to maturity. It has been observed that there is no correlation found between grain yield and number of no-extruded anthers per spike, anther extrusion % and visual score on anther extrusion. By selecting for these traits showing positive and significant correlation with grain yield there is a possibility to increase grain yield of bread wheat.

Since biological yield, number of kernels per spike number of productive tillers per plant, spike length, number of spikelets per spike had positive correlation with grain yield in the process of selection much attention should be given to them as these characters are helpful for indirect selection.

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Conflict of interest

The author declares no conflict of interest.

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