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Correlated Response of Component Traits towards Grain Yield in Cultivated Wheat Germplasm under Late Sown Condition

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Abstract—*Continual heat stress is a problem in about 7 m ha area, while terminal heat stress is a problem in about 40% of the irrigated wheat growing areas of the world. High temperature stress reduces both grain yield and quality of wheat. The progress in genetic improvement of wheat for terminal heat tolerance has been slow due to non-availability of donors for various component traits of heat tolerance. This problem can be circumvented by evaluating the uncharacterized gene pool available in the gene bank and identifying the predictor variable for grain yield under late sown condition. Towards this goal, we phenotyped 1000 diverse set of cultivated wheat accessions comprising T. aestivum, T. durum and T. dicoccum for terminal heat tolerance under late sown (heat stress condition) during winter season (Rabi) 2013-14 at NBPGR, Issapur farm in augmented block design using 8 checks C306, Raj3765, HD2967, PBW343, WR544, DWR1006, UAS415 and WH1021. We characterized these germplasm lines for 10 different morpho-physiological traits. The variability for grain yield per plot was 4 g to 1356 g per plot with the average of 582 g and for 1000 grain weight, the range was 1.9 g to 99 g with the average of 3.81 g. Days to spike emergence, days to maturity and canopy temperature were significantly correlated to grain yield in negative direction whereas grains per panicle, thousand grain weight and biomass were positively correlated. However plant height and peduncle length did not have significant correlation, although it was negative. In regression analysis (stepwise method) biomass, grains per panicle, days to spike emergence and 1000 grain weight remained in the final model for prediction (R^2 = 0.931). Based on these predictor variables, a set of 50 wheat accessions were selected. Out of these accessions, IC445595, IC543417, IC252650, IC310590, IC539561, IC443636 and IC75246 were found to be superior based on grain yield per meter and 100 grain weight in comparison to the best check Raj3765. These selected accessions will be further validated under replicated trials for screening against heat tolerance and will be used for introgression purpose in the background of elite donor germplasm to enhance yield and its stability under heat stress environments.*

1. INTRODUCTION

The importance of wheat as staple food is well known. 35% of the world population still depends on wheat for their livelihood. Due to drastic changes in climatic conditions in last 10-20 years and exponential increase in world population, tremendous pressure have exerted on agriculture to ensure the food security of the growing population of the world. Further, due to presence of number of stresses during wheat crop season, we have experienced stagnation in production in past few years. The present wheat production of the world is about 640 m tones and to feed our growing population, we have to produce between around 1050 m tones in 2020 with annual growth rate of 2.5% to the present wheat production level, which seems difficult to achieve in such small period and in the presence of so many stresses. In India, it is estimated to produce 109 million tones of wheat by 2020. In the recent past, we have all witnessed the serious threat of climate change especially due to rising temperature, drought, salinity, biotic threats like *Ug99* (in case of stem rust), prevailing races of leaf & brown rusts, powdery mildew and spot blotch. All these stresses toll heavily on the productivity of wheat crop depending upon the extent and magnitude of growth and yield reduction in crops that depends on their adaptability to changed climate. It is therefore, imperative to look for tools not only to increase the crop productivity but also ensure protection against loss of potential productivity due the environmental vagaries. Among abiotic and biotic factors, terminal heat is the major constraints limiting productivity of wheat and is a major cause of yield instability.

Terminal heat stress is a problem in 40% of the irrigated wheat areas in developing and developed countries, including the USA and Australia [1]. High temperature during crop period affect the plant growth and development which results the diverse morphological, physiological and biochemical changes in plants ultimately decrease in yield. General effects of high temperatures in developing cereal grains include a faster rate of grain development, a decrease of grain weight, shriveled seeds, reduced starch accumulation and alterations of polypeptide and lipid composition. Late sown wheat faces terminal heat stress during the critical stage called grain filling duration. Based on yearly average temperatures of 28^0C during reproductive development, it is estimated that 3-4% yield decline for every 1^0C above the optimal 15^0C [1]. The average global temperature is reported to be increasing at a rate of 0.18^0C every decade [2, 3]. Hence, development of heat tolerant varieties and generation of pre-breeding material is required to ensure the food security to the millions of the poor peoples living in the rural part of India and other developing countries [4].

During last few decades, considerable efforts have been made to improve yield performance through conventional breeding approaches. However, due to lack of variation for the heat tolerance associated traits among the cultivated varieties, it seems difficult to develop new improved wheat cultivars. Further, information regarding heat tolerance in the available wheat germplasm including land races, genetic stock, advanced breeding lines is still inadequate. India as a country is very rich as far as bio-diversity is concerned. Like other crops, we have vast genetic diversity in indigenous wheat germplasm known for hardiness, biotic and abiotic stresses resistance. Therefore, screening of wheat germplasm lines for heat tolerance might be the vital approach to assist a conventional breeder for developing heat tolerant cultivars so that yield losses could be minimized. Keeping in view the above fact, an experiment was conducted to evaluate wheat germplasm lines under late sown condition to identify the potential heat tolerant germplasm and to predict character contributing for yield.

2. MATERIAL AND METHODS

The experiment was conducted at Issapur farm of National Bureau of Plant Genetic Resources, which is located in West Delhi at a longitude 76°50’ and latitude 28°40'. The soil type is sandy loam with a pH of 8.0. Weather data was collected with the help of automatic weather station located at the experimental farm.

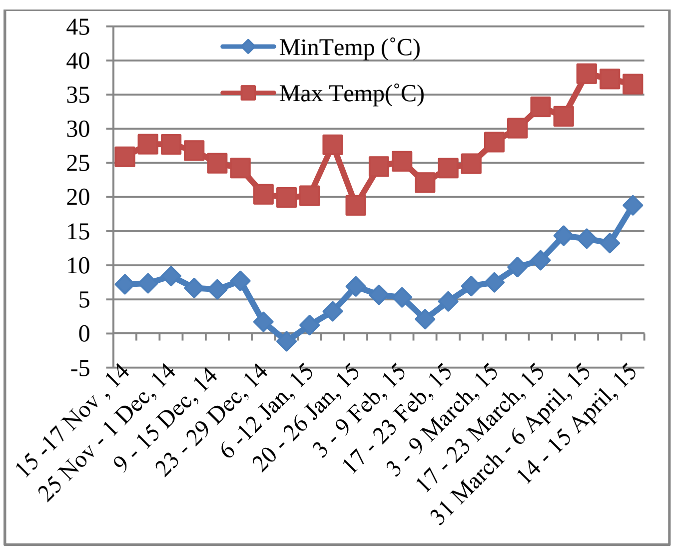

Fig. 1: Graph depicting Weekly maximum and minimum temperature variation during *rabi* 2014-15

A total of 1000 diverse set of cultivated wheat accessions selected from previous year screening and comprising *T. aestivum, T. durum* and *T. dicoccum* were grown under late sown condition during *Rabi* 2013-14 in augmented block design using 4 checks C306, Raj3765, HD2967 and PBW343. We characterized these germplasm lines for 9 different morpho-physiological traits namely days to 50% spike emergence, days to physiological maturity, plant height, peduncle length, grains per spike, 1000-grain weight, biological yield per plot, grain yield per plot and canopy temperature. The weekly maximum and minimum temperatures variation are shown in Figure 1. In the second fortnight of March, 2014 which is the grain filling period, the temperarure rose above 30^0C.

3. RESULTS AND DISCUSSIONS

The significant difference among genotypes for the traits implies the presence of substantial variation among genotypes which is central to the study of traits and gives an opportunity to plant breeders for improvement of these characters through breeding. Days to spike emergence ranged from 82 days to 114 days and days to physiological maturity ranged 117 to 138 days. Plant height ranged from 52 cm to 131 cm while peduncle length varied from 14 cm to 54 cm. The biological yield per plot varied from 580 g to 4400 g. The variability for grain yield per plot was 4 g to 1356 g per plot with the average of 582 g and for 1000 grain weight, the range was 1.9 g to 99 g with the average of 3.81 g. The coefficient of variance was maximum for grain yield followed by grains per panicle. The correlation coefficients among the various characters are presented in Table 1. Days to spike emergence, days to maturity and canopy temperature were significantly correlated to grain yield in negative direction whereas grains per panicle, thousand grain weight and biomass were positively correlated. In most of the previous studies, similar results have been reported between grain yield and related characters such as, number of spikes, spike length, number of grains per spike and 1000-grain weight [5,6,7]. Moghaddam et al. [8] also reported that yield, 1000-grain weight, and number of grain per spike were correlated. However plant height and peduncle length did not have significant correlation with grain yield, although it was negative. Evaluation of genetic variation and interrelationship between various characters can be useful for the selection of the most efficient genotypes. Furthermore, screening of wide wheat lines or cultivars has been done to improve wheat grain yield. But, selection based on the performance of grain yield alone is usually not very efficient. Thus, identifying and manipulating characters contributing to grain yield is important as it increases breeding efficiency. Multiple linear regression method is used to determine the role of yield components in increasing the yield and selection efficiency by means of few traits as the effective indicator to obtain breeding aims [9]. The results of stepwise regression analysis were calculated by considering the grain yield as the dependent variable and other characters as the independent variables. *Results showed that in regression analysis (stepwise* *method) biomass, harvest index and 1000 grain weight remained in the final model for prediction (R^2 = 0.931). (Table 2)* . Thus, the standard linear regression for grain yield was: Yield= -523 + 22.87 (harvest index) + .23 (Biomass) – 7.6 (1000 grain weight). *Based on these predictor variables, a set of 50 wheat accessions were selected. Out of these accessions, IC445595, IC543417, IC252650, IC310590, IC539561, IC443636 and IC75246 were found to be superior based on grain yield per meter and 100 grain weight in comparison to the best check Raj3765. These selected accessions will be further validated under replicated trials for screening against heat tolerance and will be used for introgression purpose in the background of elite donor germplasm to enhance yield and its stability under heat stress environments.*

Table 1: Correlation coefficient alongwith probability value between grain yield and other traits in wheat germplasm

	DSE	DPM	CT AV	PH AV	PL AV	GRP	100 GW	BYP(gm)	GYP (gm)
DSE	1.00								
	<.0001								
DPM	0.63	1.00							
	<.0001	<.0001							
CT AV	0.91	0.86	1.00						
	<.0001	<.0001	<.0001						
PH AV	-0.12	-0.13	-0.17	1.00					
	<.0001	<.0001	<.0001	<.0001					
PL AV	0.03	0.06	0.04	0.50	1.00				
	0.27	0.05	0.26	<.0001	<.0001				
GRP	0.08	-0.01	0.17	-0.22	-0.17	1.00			
	0.01	0.82	<.0001	<.0001	<.0001	<.0001			
100 GW	-0.04	0.05	0.12	-0.02	0.06	-0.03	1.00		
	0.24	0.08	<.0001	0.51	0.05	0.37	<.0001		
BYP(gm)	-0.18	-0.20	-0.17	0.31	0.08	0.16	0.12	1.00	
	<.0001	<.0001	<.0001	<.0001	0.01	<.0001	0.00	<.0001	
GYP(gm)	-0.26	-0.22	-0.20	-0.01	-0.06	0.22	0.27	0.36	1.00
	<.0001	<.0001	<.0001	0.85	0.04	<.0001	<.0001	<.0001	<.0001

Table 2: Result of stepwise regression analysis for grain yield in wheat germplasm

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-523.503	12.620		-41.484	.000		
HI	22.872	.215	.930	106.290	.000	.879	1.138
BYP	.237	.004	.558	65.739	.000	.932	1.072
TGW	-7.628	2.355	-.028	-3.240	.001	.919	1.088

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