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Genetic Divergence and Gene Source Studies in Durum Wheat Genotypes under Early Sown and Moisture Stress Conditions

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Studies were conducted on genetic divergence for 16 parameters in 102 varieties of durum wheat (*Triticum turgidum var. durum* Desf.). Analysis of variance showed significant differences among varieties for all the traits studied. Based on the magnitude of divergence value, the varieties were grouped into 16 clusters. Intra-cluster distance was maximum for cluster IV (9.6) followed by cluster XIII (7.8). The maximum inter-cluster distance was 104.0 between cluster VII and XIII, indicating high genetic divergence among varieties of these two groups. Maximum contribution towards the divergence was by carotene content (13.2%) followed by sedimentation value (9.4%), grain yield/plant (8.9%) and plant height (8.0%). Gene sources for higher number of tillers/plant (GW 1209); spike length (MPO 1243); number of grains/spike (HI 8627), carotene content (AKDW 4151); sedimentation value (NP 4); low canopy temperature at all the growth conditions (MACS 2846) and grain yield/plant (HD 4672) were identified for future breeding improvement programme.

Key Words: Cluster, D^2 analysis, Durum Wheat, Gene Source

Introduction

Durum wheat (*Triticum turgidum var. durum* Desf.) is an economically important crop and widely grown in most parts of the world, including India. It is being cultivated in an area of 10 to 11% of the world wheat area, and accounts for about 8% of the total wheat production (Ganeva *et al.,* 2011). Durum wheat is the hardest of all wheat species and consumed mainly in the form of semolina (*suji*) and fast food products (pasta products). The pasta producers require durum wheat which is hard with high yellow pigment and capable of making products with excellent cooking quality. Breeding for varieties with high yield, disease resistance, elevated yellow pigment (YP) concentration, excellent cooking quality and other desirable end-use quality traits are the objectives of durum wheat breeding programs worldwide. Genetic improvement of any species depends primarily on the extent and magnitude of genetic variability present among available germplasm for important traits. Genetic diversity is of paramount importance for heterosis and hybridization between genetically divergent parents and is expected to produce superior hybrids and desirable recombinants. Therefore, it is essential to identify genetically divergent genotypes and utilize them for breeding programme. Precise information on the nature and degree of genetic diversity helps the plant breeder in choosing the diverse parents for hybridization. Mahalanobis D^2 statistics, based on multivariate analysis serves to be a good index of genetic diversity. The present study was aimed to determine the genetic divergence in 102 durum wheat genotypes under moisture stress and early sown conditions, which will help to develop new varieties with desirable characteristics and for identification of gene source for different traits.

Materials and Methods

The field studies were carried out during *rabi* cropping seasons of 2010 to 2013 (October to March) for three years at Indian Agricultural Research Institute, Regional Station, Indore (M.P) India. The experimental material comprising 102 genotypes was sown on 16th October every year under two growing conditions *i.e.,* rainfed and restricted irrigation. Each genotype was planted in two rows of 2.5 m row length and row to row spacing of 30 cm in RBD in three replications. In rainfed condition, no irrigation was applied; whereas, in restricted irrigation condition, only one irrigation was applied at 35-40 days after sowing. Recommended agronomic practices were followed to raise the crop and all care was taken to minimize variations due to environmental and cultural conditions. Sixteen characters

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i.e., days to flowering, days to maturity, plant height, number of tillers per plant, spike length, flag leaf length, number of grains/spike, biomass yield/plant, carotene content, sedimentation value, canopy temperature I, canopy temperature II, canopy temperature III, 1000 grain weight, harvest index and grain yield/plant were recorded. Canopy temperature was measured three times i.e., vegetative stage, flowering stage and grain filling stage. The measurements were made during late morning to early afternoon of cloudless periods (11:00 to 15:00 hours) with infrared thermometer (Model LT-300 sixth sense) focused to 5:1 meter. Multivariate analysis for the estimation of genetic distance among all the varieties was carried out by using D^2 statistic analysis as suggested by Mahalanobis (1936) and clustering of genotypes was done as per the method of Tocher (Rao, 1952).

Result and Discussion

Analysis of variance showed significant differences among varieties for all the traits studied, which indicated existence of genetic variability in the varieties (Table 1). Based on the magnitude of divergence, 102 genotypes were grouped into 16 clusters (Table 2). The maximum number of genotypes were grouped in cluster XII (12) followed by cluster I (11); V (11); IX (11); X (11); IV (8); XVI (7) and one each in cluster VI, III, II, VIII, XIII, VII, XI and XIV. Intra-cluster distance was maximum for cluster IV (9.6) followed by 7.8 for cluster XIII. However, clusters VII, XI and XIV had no intra-cluster distance as they were represented by a single genotype. The maximum inter-cluster distance (104.0) was observed between clusters VII and XIII indicating the presence of highly genetic divergent varieties in these two groups. Minimum inter-cluster distance (9.0) was observed between clusters IX and X showing their close proximity. However, in all cases inter-cluster distances were greater than the intra-cluster distances indicating the presence of genetic diversity among the varieties between different clusters (Table 3). The cluster means indicated substantial variation among 16 clusters (Table 4). Cluster mean values indicated that maximum number of tillers/plant was found in cluster XIII with 3 varieties viz., A 9-30-1, Amrut and CDW 04. Maximum spike length was seen for cluster XIV with one variety (NP 404). Varieties (HI 8627 and CPAN 6236) in cluster VII and VIII showed maximum number of grains/spike. Clusters II, VIII and VII showed high carotene content. Cluster means of XIII, VIII and XII showed maximum sedimentation values. Low mean canopy temperature at all the growth stages was found in clusters XIV, IX and I. Higher mean values of 1000 grain weight was observed among clusters XI and III. Clusters XI, VII, III, XV and VI showed high grain yield/plant.

Genotypes *viz.*, HD 4672, HI 8627, V 21, HD 4676 and HI 8638 showed higher grain yield/plant in cluster XI, VII and III respectively. Maximum contribution towards total divergence was 13.2% by carotene content followed by sedimentation value (9.4%). On the contrary, the other characters have given very little contribution to total divergence for enabling clear discrimination of the genotypes (Table 4). Composition of genotypes among

Table 1. Range, mean, standard error and co-efficient of variance for different characters in durum wheat

Parameters	Mean	Range		SE(±)	CV(%)
		Minimum	Maximum		
Days to flowering	74	58	92	0.3	0.5
Days to maturity	125	111	139	0.3	0.3
Plant height	83	60	109	0.5	0.8
No. of tillers	7.7	5.8	10.3	0.3	4.3
Spike length	7.0	5.2	8.9	0.1	1.0
Flag leaf length	19.0	12.9	23.0	0.2	1.4
No. of grains/spike	41	29	55	0.5	1.4
Biomass/plant (g)	49.3	39.5	60.0	0.1	0.4
Carotene content (ppm)	4.3	2.8	7.8	0.1	1.9
Sedimentation value (ml)	33	20	49	0.4	1.5
Canopy temperature I	20.8	18.2	23.7	0.3	1.9
Canopy temperature II	22.5	20.3	54.0	1.4	7.7
Canopy temperature III	25.2	22.4	27.8	0.3	1.3
1000 grain weight (g)	42.7	31.5	59.4	0.6	1.7
Harvest index (%)	37.6	27.0	54.6	0.6	1.8
Grain yield/plant (g)	15.8	11.2	22.9	0.3	2.5

Table 2. Composition of the clusters of durum wheat genotypes under moisture stress in early sown conditions

Cluster	No. of genotypes	Composition of genotypes
I	11	CDW 04, HI 8498, HI 8691, IWP 5070, MACS 2846, MACS 3125, MPO 1106, MPO 1215, NIDW 70, Raj 1555; Raj 6566
II	4	AKDW 4151, V21/23, WH 896; MPO 1243
III	5	HD 4676, HI 8638, HI 8671, MACS 9; V21
IV	8	GW 1170, HD 4502, HI 7747, HI 8381, HI 8591, MACS 3061, MACS 3063; Raj 6516
V	11	GW 1, GW 1114, GW 1245, HG 110, HI 8722, Jay, Karnataka Local, MACS 1967, N 59, NIDW 15; Sarangpur local
VI	6	Baxi 228-18, Dohad Local, GW 2, HI 8550, IWP 5004-1; Kathia 25
VII	1	HI 8627
VIII	4	CPAN 6236, GS 27, Raj 6562; WH 912
IX	11	B 4446-WA, B 4447-BA, DBP 01-09, GW 1240, HI 8666, IWP 5007, Jairaj, Line 1172, Raj 6069, VD 97-15; Vijay
X	11	Bansi Local, DWL 5023, GW 1209, GW 1225, GW 1244, HI 8645, IWP 5013, Malvi Local, Mandsour Local, NI 5759; NIDW 9
XI	1	HD 4672
XII	12	AKDW 4240, Altar 84, DBP 01-11, GW 1139, HI 8592, HI 8653, HI 8663, MACS 2694, NIDW 295, PDW 215, PDW 233; PDW 245
XIII	3	A 9-30-1, Amrut; CDW 04
XIV	1	NP 404
XV	6	A 206, Bijaga Red, Bijaga Yellow, DWR 137, JU 12; Meghdoot
XVI	7	DBP 02-08, Guji 'S', HD 4709, Motia, MPO 215, Sawer local; Trinakaria

Table 3. Average intra- and inter-cluster D^2 values between the clusters of durum wheat genotypes under moisture stress in early sown condition

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI
I	3.6															
II	25.0	7.3														
III	11.6	32.5	6.3													
IV	30.3	21.2	49.0	9.6												
V	10.2	21.2	13.0	30.3	6.3											
VI	22.1	18.5	23.0	22.1	13.7	7.29										
VII	50.4	57.8	34.8	64.0	51.8	57.8	0.0									
VIII	51.8	21.2	59.3	23.0	51.8	22.1	64.0	6.8								
IX	14.4	29.2	28.1	27.0	12.3	29.2	74.0	53.3	5.3							
X	13.0	22.1	24.0	15.2	9.6	10.9	60.8	36.0	9.0	7.3						
XI	31.4	37.2	14.4	51.8	24.0	27.0	47.6	60.1	39.7	26.0	0.0					
XII	10.2	9.6	27.0	13.0	11.6	13.7	56.3	23.0	9.6	14.4	33.6	5.8				
XIII	24.0	34.8	39.7	50.4	15.2	22.1	104.0	60.8	21.2	17.6	46.2	20.3	7.8			
XIV	30.3	42.3	42.3	53.3	16.8	37.2	77.4	81.0	31.4	23.0	46.2	32.5	24.0	0.0		
XV	17.6	32.5	18.5	41.0	13.0	10.9	59.3	50.4	22.1	11.6	20.3	19.4	13.0	19.4	4.4	
XVI	33.6	17.6	37.2	14.4	28.1	116	65.6	16.0	29.2	11.6	29.2	14.4	37.2	44.9	26.0	7.3

the clusters infer that distribution of genotypes from different geographical locations into one cluster may be due to presence of some common genes controlling the most important characters through modifying effect of micro and macro environment affecting genetic diversity and some degree of ancestral relationship among the genotypes (Sangwan *et al*., 2004) . Another feature that genotypes from the same location were placed in separate clusters indicates wide diversity among genotypes from the same location. This showed that the geographical diversity may not necessarily be related to genetic diversity in this species. The present findings are in

Table 4. Mean values of the characters in clusters of durum wheat genotypes under moisture stress in early sown conditions

Characters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	Contribution (%)
DF	67	78	66	83	66	78	79	89	68	76	71	76	67	79	70	85	6.4
DM	121	129.	122	129	121	126	128	135	121	125	126	126	121	125	123	135	2.5
PH	76	77	83	70	84	99	83	97	76	83	80	76	93	93	98	91	8.0
NT	7.4	7.3	7.3	6.9	7.7	7.4	7.1	7.2	7.9	8.3	9.6	7.6	9.7	9.1	8.3	7.9	5.7
SL	6.7	7.7	6.9	6.9	7.7	7.6	7.5	7.0	5.9	6.7	7.1	6.9	7.7	8.8	7.7	6.6	5.8
FLL	18.5	18.6	19.5	17.1	20.3	19.6	18.9	15.7	18.7	19.7	19.6	18.5	21.1	22.4	21.7	17.9	5.5
NOG	43	41	43	40	42	42	55	54	37	37	42	42	36	35	41	37	6.3
BM	53.2	51.4	56.2	46.5	52	49.5	49.3	42.6	48.1	49.5	51.9	46.8	49.3	54.1	46.7	47.4	5.1
Caro	3.9	7.7	4.5	4.1	4.0	3.9	6.6	7.5	4.2	3.5	5.3	4.8	3.6	3.8	3.5	4.8	13.2
SDS	36	37	36	25	32	35	30	42	32	30	26	41	49	27	33	30	9.4
CT I	18.9	21.2	20.1	22.1	20.2	21.7	20.7	22.7	19.2	21.1	20.2	20.8	20.5	18.7	20.3	21.5	2.9
CT II	20.7	23.2	20.7	25.0	21.6	23.1	22.6	24.2	20.7	22.9	22.0	22.7	22.0	20.7	21.6	23.5	5.4
CT III	23.5	26.1	24.2	26.4	24.7	26.0	25.2	27.1	23.9	25.6	24.5	25.4	24.5	23.4	24.4	26.3	2.3
GW	40.4	42.4	57.1	38.9	42.5	55.7	45.4	44.1	37.0	41.8	59.0	39.0	42.1	35.9	48.5	48.4	7.8
HI	39.0	36.4	41.8	37.5	38.0	35.2	53.6	37.3	37.6	37.6	38.4	37.0	32.1	39.6	36.8	35.9	4.7
GY	15.6	15.1	22.4	14.4	16.1	21.8	22.6	16.2	13.8	15.7	22.7	14.2	13.3	13.9	22.1	16.9	8.9

DF= Days to flowering, DM= Days to maturity, PH= Plant height, NT= No. of tillers, SL= Spike length, FLL= Flag leaf length, NOG= No. of grains/spike, BM = Biomass yield/plant, Caro = Carotene content (ppm), SDS = Sedimentation value (ml), CT I= Canopy temperature at vegetative stage, CT II= Canopy temperature at flowering stage, CT III= Canopy temperature at grain filling stage, GW= 1000 grain weight (gm), HI = Harvest index (%) and GY = Grain yield/plant (g)

Table 5. Gene sources for all characters in durum wheat

Characters	Potential	Varieties
Days to flowering	58, 59, 60, 60, 60	Jay, MACS 9, Vijay, V 21 and NP 4
Days to maturity	111, 117, 118, 118, 118	V 21, HI 8691, Jay, IWP 5070 and Raj 6566
Plant height (cm)	62, 64, 64, 66, 69	IWP 5007, GW 114, GW 1240, HI 7747 and GW 1170
No. of tillers	9.7, 9.6, 9.1, 9.0, 8.9	GW 1209, Amrut, B 4447-BA, NP 4 and GW 1
Spike length (cm)	8.8, 8.6, 8.5, 8.3, 8.2	MPO 1243, NP 404, GW 1245, Karnataka local and Kathia 25
Flag leaf length (cm)	22.7, 22.6, 22.6, 22.4, 22.2	A 206, Bijaga yellow, Dohad local, NP 404 and Karnataka local
No. of grains/spike	54.6, 53.9, 50.8, 49.3, 48.8	HI 8627, CPAN 6236, Altar 84, HI 8550 and HI 8638
Biomass/plant (g)	60.0, 58.6, 58.4, 56.5, 56.4	MACS 9, MPO 1243, HI 8671, GW 1245 and NIDW 15
Carotene content (ppm)	7.7, 7.5, 6.6, 6.5, 6.3	AKDW 4151, WH 896, MPO 1243, V21/23 and WH 912
Sedimentation value (ml)	49.2, 41.8, 40.9, 40.6, 40.6	NP 4, CPAN 6236, IWP 5070, A 206 and Dohad local
Canopy temperature I (^{O}C)	18.7, 18.9, 19.2, 19.2, 19.3	MACS 2846, NP 404, MACS 1967, NP 4 and Jairaj
Canopy temperature II (^{O}C)	20.7, 20.7, 20.7, 20.8, 20.9	Bijaga yellow, HI 8638, Raj 6069, MACS 2846 and HI 8691
Canopy temperature III (^{O}C)	23.4, 23.5, 23.9, 23.9, 24.0	MACS 2846, HI 8638, V 21, MACS 1967 and Line 1172
1000 grain weight (g)	59.0, 57.1, 55.7, 55.6, 53.3	HD 4672, Baxi 228-18, V 21, HI 8550 and Bijaga red
Harvest index (%)	53.6, 44.4, 43.4, 42.9, 41.7	HI 8627, HD 4676, HI 8671, GW 1225 and HI 8638
Grain yield/plant (g)	22.7, 22.6, 22.4, 22.1, 21.8	HD 4672, HI 8627, V 21, HD 4676 and HI 8638

agreement with Deshmukh *et al*., (1999) and Lad *et al.,* (2002) in durum wheat. Thus, the complex composition of clusters indicates that geographical diversity is important but it is not the sole factor determining the genetic diversity (Murthy and Arunachalam, 1966). Based on the analysis, varieties with gene source for all the important parameters have been identified (Table 5). Gene sources for days to flowering (Jay); days to maturity (V 21) and plant height (IWP 5007), whereas GW 1209, MPO 1243, HI 8627 and MACS 9 are gene source for number of tillers, spike length, number of grains/spike and biomass/plant, respectively as these are found superior for the particular traits. MACS 2846 is the gene source for low canopy temperature at all the growth conditions. Since low canopy temperature is the important selection parameter to identify high yielding genotypes, therefore, genotypes showing low canopy temperature values will be utilized for future selection and breeding. HI 8638 with low canopy temperature and high grain yield can be a gene source for grain yield/plant. Keeping these points in view and with the changing climatic conditions, there is a need to select gene sources in durum wheat genotypes adaptable to early heat stress situations (early sown condition) with minimum irrigation, which will help to improve the heat tolerant character. It will certainly help in increasing its area, production and productivity.

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