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Effect of maturity date on cultivar variation and association for growth duration characters and grain yield in bread wheat

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ABSTRACT

The study was under taken using 21 selected bread wheat genotypes by classifying according to their maturity time in three maturity group, *i.e.*, early, mid-early and late group for comparative studies to know the effects of maturity time on cultivar variation for the characters related to growth duration and their associations among themselves and with grain yield. Significant variations for the characters under study were observed among the genotypes and genotypes within the maturity group, except for grain yield per plant in mid-early group. GW 173 was earliest among the genotypes studied. Lok 1 and Sonalika had short vegetative and long grain filling period and spent the highest per cent (42%) of total life span to grain filling periods. However, grain yield per plant was the highest in Lok 42. The average value for maturity groups indicated that early group genotypes were 15 days shorter for vegetative and 6 days longer for grain filling periods with 25% higher yield than late group genotypes. The effect of maturity time was observed for correlations among the characters too. Significant positive correlation between days to ear emergence and maturity and significant negative correlation between days to ear emergence and grain filling index of late group became non-significant in early group. The correlation of grain yield per plant with days to ear emergence and maturity shifted from negative in late group to positive in early group. In fact, changes in associations could be due to mating system used for generating variability and selection practiced for obtaining more and more early types with desirable character combinations.

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Key words : Grain filling period, Vegetative period, Grain yield, Maturity effects, Bread wheat

INTRODUCTION

The grain yield is directly dependent on sink size, which is largely determined during the vegetative period and on the photosynthetic capacity of the crop during the grain filling period (Binghum, 1969). Thus, both vegetative and grain filling periods are important for achieving high yields in wheat. Moreover, many researchers have reported the association between yield and growth duration characters like days to anthesis and days to maturity. If sizeable heritable differences occur within a species in the duration of vegetative and grain filling periods, the opportunity exists for improving yield through altering the length of this two growth periods in a breeding programme. Thus, shortening crop duration is a very important consideration in crop productivity and wheat breeders always tended to select plants for earliness. As a result, the modern varieties of grain crops in general and wheat in particular are more earlier than those of older ones. The present study was designed to know the effect of differences in maturity time on cultivar variation for growth duration characters and grain yield in bread wheat.

MATERIALS AND METHODS

The material consisted of 21 bread wheat genotypes, which were selected based on maturity time and classified into three maturity groups, *i.e.*, early, mid-early and late. Each maturity group included seven genotypes. The experiment was conducted in timely sown condition during *Rabi* season at the Experimental Farm, Wheat Research Station, Junagadh Agricultural University, Junagadh in Randomized Block Design with the additional restriction on randomization that genotypes within the maturity group appear together in each of the three replications. Each genotype was sown in three rows of 3 meter length with the inter- and intra-row spacing of 22.5 x 10 cm. The crop was fertilized by 120-60-0 NPK kg/ha as recommended dose of the region. Half of the nitrogen and total quantity of phosphorus was given as basal dose. The remaining half quantity of nitrogen was applied as topdressing at the 21 days after sowing. Crop was irrigated 11 times during life cycle as per recommended schedule. Pendimethaline (2.5 a.i.ha^{-1}), a pre-emergence weedicide was sprayed 48 hrs after sowing for weed control. Chloropyriphose at the rate of 25 kg a.i. ha^{-1} was applied

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in soil by drenching for controlling termites. Other recommended cultural practices were followed to harvest the good yield.

Data were collected for six characters. Randomly selected ten plants from middle row which were tagged before ear emergence used for this purpose. Days to ear emergence measured as days from date of sowing to the date on which the tip of upper most spiklet of main ear emerged beyond the auricles of flag leaf. Days to maturity calculated from date of sowing to the date on which approximately 75% glumes of primary spikes turned yellow. Vegetative period estimated as duration between sowing date to the date of anthesis (anther extrusion from central florets of main spike). The grain filling period was calculated as difference between days to maturity and days to anthesis. Ratio of grain filling period to days to maturity was considered as grain filling index and grain yield per plant (g) was recorded as usual. The analysis of variance was conducted for each character as per experimental design and correlation coefficients (phenotypic) were calculated according to Al-jibouri *et al.* (1958).

RESULTS AND DISCUSSION

The mean squares due to genotypes and maturity groups were significant for all the characters (Table 1), indicating sufficiently large variation among the genotypes and between the maturity groups. However, mean squares due to maturity groups were quite higher than those calculated including all the 21 genotypes, indicated that selection of genotypes and their classification according to maturity time was proper and all the three classes were distinct from each other. Also, all the characters expressed significant variations among the genotypes within each maturity group, except grain yield per plant in mid-early group.

The mean values of 21 genotypes presented in Table 2 revealed that duration of ear emergence ranged from 47 to 70 days and maturity ranged from 81 to 98 days. Variation for length of vegetative period was observed from 50 to 72 days and for grain filling period was observed from 23 to 37 days. The grain filling index, the ratio of grain filling period to days to maturity, registered the range of variation from 24 to 42%. Grain yield also expressed significant variation among the genotypes ranging from 4.42 to 9.90 g per plant. Variations in duration of ear emergence, maturity and grain filling period in spring wheat germplasm have been reported (Tiwari, 2007). Nass and Reiser (1975) reported the variation for grain filling index (per cent period under grain filling) in ten spring wheat cultivars.

There were significant differences among the maturity groups (Table 3) for the characters under study. On an average, early group genotypes showed time to emergence and maturity 15 and 9 days less than those of late group genotypes, respectively, but had expressed 15 days shorter vegetative period and 6 days longer grain filling period. This indicated that changes in length of vegetative and grain filling period in modern wheat varieties have been occurred as a results of plant breeders' tendency to select for more and more early and high yielding types. In the conditions like Saurashtra, where the later part of the growing period is exceptionally hot and dry to occur frequently, short vegetative period through earlier ear emergence and long grain filling duration as observed in the present study should be the alternative strategies for improving wheat productivity. The average values of grain filling index indicated that wheat cultivars representing late, mid-early and early maturity group spent 29, 35 and 39 per cent of their growth cycle in grain filling, respectively. An extended grain filling duration would increase the availability of photo-assimilates leading to higher grain yield. Early group in

Table 1 : Analysis of variance for growth duration characters and grain yield of 21 bread wheat genotypes classifying into three maturity groups

Source	df	Duration (Days)				Grain filling index	Grain yield / plant
		Ear emergence	Maturity	Vegetative period	Grain filling period		
Replications	2	1.84	0.31	0.27	0.20	0.01	3.76
Genotypes	20	140.62**	58.17**	144.72**	34.71**	0.42**	7.09**
Maturity groups	2	1155.48**	412.22**	1244.89**	311.18**	3.70**	21.90**
Genotypes/ early group	6	7.94**	12.65**	7.52**	15.00**	0.06**	10.02**
Genotype/ mid-early group	6	12.95**	8.86**	13.41**	6.65**	0.07**	1.86
Genotype/ late group	6	62.70**	18.38**	46.40**	19.77**	0.23**	4.45*
Error	40	0.90	1.82	1.11	0.85	0.01	1.74

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Mean values for growth duration characters and grain yield of 21 bread wheat genotypes of three maturity groups

Maturity group/ Genotype		Duration (Days)				Grain filling index	Grain yield / plant
		Ear emergence	Maturity	Vegetative period	Grain filling period		
Early							
1.	Sonalika	47	85	50	35	0.42	7.19
2.	GW 173	47	81	51	31	0.38	5.35
3.	WH 147	49	85	51	34	0.40	9.89
4.	Lok 42	51	87	54	33	0.38	9.90
5.	Raj 3077	51	84	53	31	0.37	7.52
6.	Lok 1	48	87	50	37	0.42	9.89
7.	CgnxKal-Bb	49	85	52	33	0.39	6.42
Mid-early							
8.	GW 496	52	87	54	33	0.38	8.62
9.	GW 273	54	88	56	31	0.36	9.14
10.	J1-7	55	90	58	32	0.36	9.36
11.	J 40	55	90	58	32	0.36	8.30
12.	BR 156	57	91	60	31	0.33	7.53
13.	GW 190	57	88	60	28	0.32	7.21
14.	DL 803-3	54	88	58	30	0.34	8.19
Late							
15.	NP 824	59	93	62	31	0.34	6.65
16.	PBW 316	62	94	66	28	0.30	6.83
17.	J 24	59	92	63	29	0.31	8.34
18.	HI 1077	63	92	66	25	0.27	6.99
19.	GW 89	64	94	67	27	0.29	6.36
20.	Raj 1777	70	98	71	27	0.27	5.59
21.	CPAN 1689	70	96	72	23	0.24	4.42
	S.E.±	0.55	0.78	0.61	0.53	0.01	0.76
	C.D. (P=0.05)	1.56	2.23	1.73	1.52	0.01	2.17

the present study recorded significantly shorter vegetative period and significantly longer grain filling period (desirable characteristics) than mid-early and late maturity groups. However, the mean grain yield per plant of early group was non-significantly lower than mid-early group but 25% higher than late group. Nass and Reiser (1975) reported that rate rather than period of grain filling is important for improving wheat productivity. They suggested that a variety with a shorter grain filling period but a faster filling rate can give as much or even higher grain production than the others having longer filling period but slower filling rate.

Comparisons of mean values of different maturity groups showed that large directional changes might have been occurred during the course of evolution of more and more early wheat varieties (Table 3). Time of ear emergence and maturity and vegetative period decreased steadily, while grain filling period and grain filling index increased steadily with the increasing in earliness (mid-early and early group, respectively). However, such trend was not observed for grain yield per plant and it was slightly higher in mid-early group than early group. But the examination of grain yield data of individual genotypes (Table 2) gives the indication of such changes. Some mid-early cultivars produced higher grain yield than late cultivars and some early group cultivars recorded still higher grain yield than mid-early cultivars. Clearly, the increase in yield potential of wheat has also been obtained with increasing earliness. These changes in characters indicated that more and more of total biomass produced was being partitioned to grain production and less and less to the vegetative growth (Allard, 1999).

Further, the critical examination of mean values of individual genotypes suggested that a particular combination of the length of vegetative and filling periods of Lok 1 and Sonalika was observed to be resulted in higher grain yield. In fact, a combination that is favourable under one environment may be unfavourable under another. Fortunately, both these genotypes are released and best suited varieties of the region for timely and late

Table 3 : Mean of growth duration characters and grain yield for three maturity groups in bread wheat

Maturity group	Duration (Days)				Grain filling index	Grain yield/ plant
	Ear emergence	Maturity	Vegetative period	Grain filling period		
Early	49	85	52	33	0.39	8.08
Mid-early	55	89	58	31	0.35	8.34
Late	64	94	67	27	0.29	6.45
S.E.±	0.2	0.3	0.2	0.2	0.01	0.29
C.D. (P=0.05)	0.6	0.8	0.7	0.6	0.02	0.82

Table 4 : Phenotypic correlation coefficients among the growth duration characters and grain yield in bread wheat genotypes after classifying into three maturity groups

Characters		Days to maturity	Vegetative period	Grain filling period	Grain filling index	Grain yield / plant
Days to ear emergence	E	0.43	0.77*	-0.12	-0.38	0.40
	M	0.77*	0.94**	-0.63	-0.94**	-0.95**
	L	0.77*	0.91**	-0.71	-0.85*	-0.62
Days to maturity	E		0.35	0.67	0.42	0.43
	M		0.72	0.04	-0.43	0.09
	L		0.76*	-0.17	-0.41	-0.63
Vegetative period	E			-0.36	-0.65	0.16
	M			-0.67	-0.94**	-0.95**
	L			-0.76*	-0.90**	0.63
Grain filling period	E				0.94**	0.39
	M				0.90**	0.83*
	L				0.97**	0.34
Grain filling index	E					0.25
	M					0.81*
	L					0.48

* and ** indicate significance of values at P=0.05 and 0.01, respectively.
E= Early group, M=Mid-early group and L=Late group

sowing conditions. Thus, Lok 1 and Sonalika of early group genotypes having short vegetative and long grain filling periods provides an opportunity for incorporating these characteristics in late heading genotypes.

Phenotypic correlations among grain yield and growth duration characters (Table 4) revealed that in mid-early group but not in early and late group grain yield per plant correlated negatively with days to ear emergence and vegetative period and significantly positively with grain filling period and grain filling index. Non-significant association between these traits in early and late group indicated the existence of gene systems of grain yield per plant independent to growth duration traits. This may be expected when late and early maturing genotypes are grown under timely sown conditions. In the Saurashtra region, winter is very short and three sowing conditions are prevailing, *i.e.*, early sowing at the end of October, timely sowing at mid of the November and late sowing at the 1st December and onwards. One can expect better performance, if late maturing varieties are grown in early sown condition, medium maturing varieties in timely sown condition and early maturing varieties in late sown condition, as can coinciding cold spell at reproductive phase. Undoubtedly, early and late group genotypes of the present study grown under timely sown condition might have experienced heat stress at early heading or late grain filling phase leading to non-significant correlation between grain yield and growth duration traits. This indicated that vegetative and grain filling periods were not important parameters of higher grain yield in early genotypes of present study. Earlier, some other scientists have reported that not the duration of grain filling but the rate at which grains are being filled (Bigham, 1969; Nass and Reiser, 1975) is an important consideration. Bruckner and Frohberg (1987) suggested that rate of grain filling is the determinant of kernel size and selection for high grain filling rate through selection for high kernel weight is possible. Kalariya (2007) in his study observed significantly increased 100-grain weight in the early group as compared to mid-early and late group genotypes.

Vegetative period but not grain filling period was positively correlated with days to ear emergence in all the maturity groups. Days to maturity showed significant positive correlation with vegetative period but non-significant correlation with grain filling period. Since vegetative and grain filling period make up to days to maturity, they are expected to be correlated with it. Our results are deviating from this expectation. This may be possible if lengths of vegetative and filling periods are controlled by separate genetic systems (Knott and Gebeyehou, 1987). In fact, increasing temperature during ripening period tend to hasten physiological maturity which restricted the length of growing period. Thus, if a line had a long vegetative period, it was forced to fill it kernels in short period, whereas if it had a short vegetative period, a longer period was available for grain filling.

A comparison of correlation values of different maturity group indicated that certain changes either in strength or in direction of correlation might have been arisen during the course of evolution of more and more early cultivars. For example, in early group correlations for days to ear emergence with days to maturity and grain filling index were observed to be non-significant as against significant positive in former and significant negative in later pair of characters in late group. The direction of correlations shifted from negative in late group to positive in early group, though non-significant, for grain yield per plant with days to ear emergence and days to maturity, and for days to maturity with grain filling period. Such changes in magnitude and direction may occur as a result of reshuffling and breakage of linkage due to mating system used for generating variability and selection practiced for obtaining more and more early genotypes with desirable character recombination.

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