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Control of Genetic Variation in Stem Diameter, Number of Vascular Bundles and their Relationships with Grain Yield under Heat Stress in Bread Wheat

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Abstract:

The genetic system controlling variability in stem diameter and number of vascular bundles in wheat was investigated in an 8 parent diallel cross grown in favorable environment (normal sowing date) and heat stress environment (late sowing date). For the two stem attributes genes with additive effects were operating with non-allelic gene interaction being involved for number of vascular bundles under normal sowing date, heat stress reduced stem diameter by 14.1% on average while the average reduction in vascular bundles amounted to 10.65%. The narrow-sense heritability estimates were reasonably. high and comparable in the two environments being 0.78and 0.62 for stem diameter, 0.78 and 0.73 for number of vascular bundles under favorable and heat stress conditions, respectively. The two stem attributes were positively and significantly correlated in both favorable ($r = 0.77$, $p < 0.01$) and heat stress environment ($r = 0.69$, $p < 0.01$), indicating the considerable proportion of the variation in stem diameter is accounted for by variation number of bundles in the stem. The impact of heat stress was grater on grain yield per spike (38.5% reduction) than on 1000 kernel weight (22.1% reduction). For the two yield components analyzed, the narrow-sense heritability was rather low being 0.47 and 0.40 for grain yield per spike in normal and stress environments. Stem diameter was significantly correlated with both; 1000 kernel weight under favorable ($r = 0.59$, $p < 0.01$) and heat stress condition ($r = 0.59$, $p < 0.01$). Stem diameter was also correlated with grain yield per spike in the two environments ($r = 0.47$, and 0.42, $p < 0.01$). Meanwhile, number of vascular bundles was significantly correlated with 1000 kernel weight under favorable conditions only ($r = 0.53$, $p < 0.01$) and with grain yield per spike on the two environments ($r = 0.47$ and $r = 42$, $p < 0.01$). Moreover, the positive significant association between stem diameter and 1000 kernel weight was consistently displayed in the 9 F_2 segregating populations analyzed. Meanwhile the association of stem diameter with grain yield per spike was significantly positive in only six of the 9 F_2 populations. The results of the present study clearly demonstrate the utility of selecting for stem diameter for improving heat stress tolerance as an easy storable character with reasonable high narrow-sense heritability which will increase storage ability of assimilates in the stem via affecting number of vascular bundles.

Keywards: heat stress, vascular bundles, stem diameter in wheat.

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Introduction:

In wheat growing areas with a Mediterranean climate such as that of Egypt, temperature starts to rise while, plants reach the flowering stage and anthesis. The ensuing heat stress that develops later coincides with grain filling causing 10-15% loss in grain yield due primarily to reduced single kernel mass (Wardlaw and Wrigley, 1994). Evidently, with the current global warming phenomenon, that affects the whole world, the impact of heat stress is becoming a serious constrain to wheat productivity. Under elevated temperature during grain filling, photosynthesis rapidly declines which reduces the supply current assimilates to the grains leading to reduction in kernel weight (Wardlaw and Willenbrink, 2000). At the same time, high temperature at grain filling accelerates plant respiration (Gent and Kiyomoto, 1985 and McCoullogh and hunt , 1989). With the older leaves of the plant reaching natural senesces, the flag leaf alone can not supply the assimilates needed for both respiration and grain filling under terminal heat stress (Rawson and Evans, 1983). The wheat plant relies on the remobilization of the stem reserves of water-solube carbohydrates into the developing grains (Blum *et al.,* 1994 and Gent, 1994). Stem attributes, either morphological or anatomical will impact the storage capacity for the assimilates and consequently, the grain filling through remobilization of assimilates. Recent studies revealed that stem diameter and stem density as well as stem specific weight were associated with grain yield per spike and single kernel mass (Ehdaie *et al.,* 2006a), through allowing greater provision for grain tilling under heat stress. Evidently, the vascular system of the stem Particularly the phloem of the vascular bundles is the storage facility of the plant for the assimilate formed before anthesis. Variation in stem diameter might therefore be a reflection of variation in number of vascular bundles in the stem selection for stem diameter for enhancing heat stress tolerance might therefore produce its effect though changing number of vascular bundles and consequently the storage capacity of the stem. The present study examines the genetic system controlling stem diameter, number of vascular bundles and their correlation with grain yield per spike and single kernel mass under heat stress.

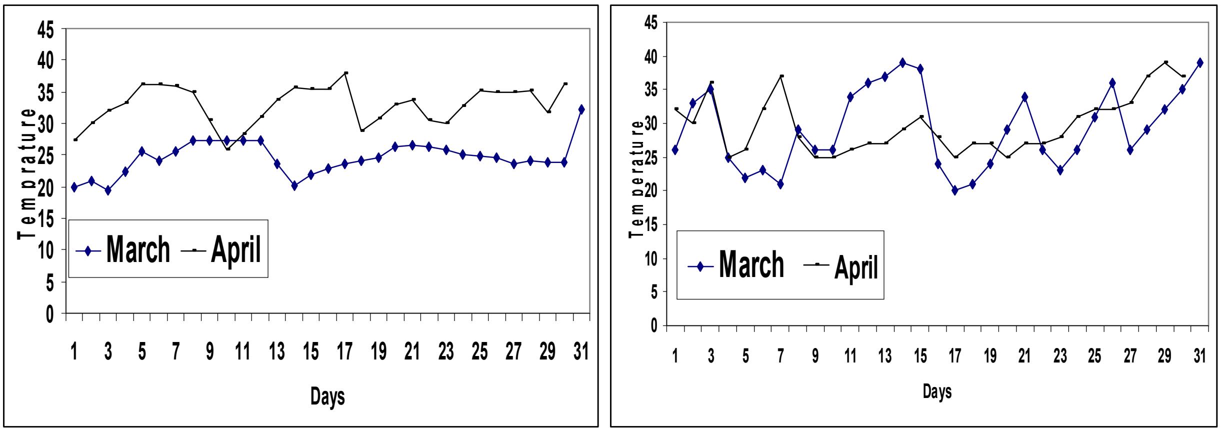
Materials and Methods:

Eight local genotypes of bread wheat (*Triticum aestivum* L.) which are quite variable in stem diameter, spike length, plant height and yield were chosen for this study. The name and description of each genotype are presented in Table1.

Table (1): Designation number and name of each of the eight genotypes with plant description.

Code number	Name	Description
1	Giza-168	Medium stem diameter and spike length – short stature
2	Sids-1	Medium stem diameter and spike length – tall stature
3	Gimmeiza-7	Large stem diameter- medium spike length – medium stature
4	Line - 11	Medium stem diameter- long spike length – tall stature
5	Line - 14	Small stem diameter- long spike – tall stature
6	WA–25-35	Small stem diameter-medium spike –tall stature
7	WA–96-93	Medium stem diameter-medium spike length – medium stature
8	Sids-12	Large stem diameter- medium spike – medium stature

This study was carried out in a private farm near Sohag Faculty of Agriculture Farm during 2010/2011, 2011//2012, 2012/2013 seasons. In 2010/2011 sowing season, the eight genotypes were crossed as parents in all possible combinations in order to establish a half-diallel set of crosses.



(a) (b)

Fig. (1): Maximum daily temperatures during March, April 2012 (a) and 2013 at the experimental Site.

In 2011 / 2012 season, the eight parents and their 28 F_1 hybrids were sown in two sowing dates, namely the normal (favorable) date of 30th of November and a late sowing date (30 of December) so as to subject the plants to heat stress after flowering time when temperature rises during March and April. The maximum daily temperature recorded at the experimental site in the two seasons reveal a gradual rise in temperature by the end of the growing season to fluctuate around 35° in April which coincided with the post-anthesis and grain filling stage, (Fig. 1). For each sowing date randomized complete block design with three replications was used. In each block, the 36 entries of the dialel table were represented by a plot of 6 plants spaced 30 cm apart within rows set 50 cm from each other. At anthesis, the diameter of the six plants of each entry was measured in the middle of the second basal internode using a venire caliper. Meanwhile, a five centimeter long piece of the main stem were cut from the middle of the second internode of a randomly chosen plant of each entry in each block which was killed and fixed in a 3:1solution of absolute ethanol to glacial acetic acid which was removed after 24 hours into vials containing 70% ethanol and stored in a refrigerator. The total number of vascular bundles in the main stem was determined in very thin (15 to 25 µ thickness) cross sections of the specimens taken from the main stem which were stained with sefranin .Vascular bundles were counted in the cross section under the low power (4X) of a light microscope. For monitoring the segregation for stem diameter and other yield attributes, nine F_2 populations out of the 28 populations of the diallel table were chosen and sown in the field along with the eight parents in 2012 / 2013 season. The nine F_2's were sown in three replicated blocks with each cross represented in each block by 10 rows of 20 plants, with plants spaced 20 cm within rows while rows were set 30 cm from each other. Stem diameter was measured and recorded for 200 F_2 plants of each cross at anthesis. For both the F_1 and F_2 plants, the following characters were recorded:

1. Main stem diameter (mm)
2. Number of vascular bundles
3. 1000 kernel weight (g)
4. Grain yield per spike (g)

Total number of vascular bundles in the stem was scored for the F_1 diallel cross in the two sowing dates

Biometrical analysis:

Data were subjected first to a two-away analysis of variance. After establishing the significances of the differences between genotypes (parents and F_1's), the diallel analysis (Haymen 1954 a & b) was employed.

Results:

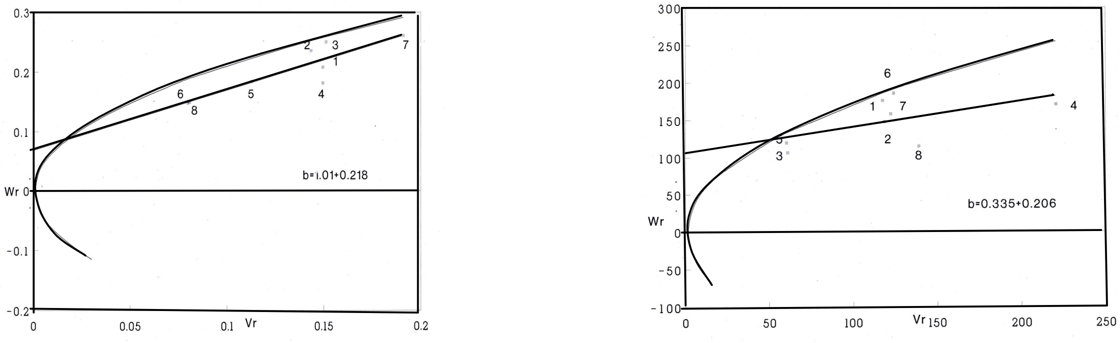
1-Main stem diameter:

The means of main stem diameter of the eight parents and their 28 hybrids are presented in Table 2. The parental means ranged from4.57 to 6.63 mm with an average 5.68 mm for Favorable environment (the 1st sowing date). For the2nd sowing date, the parental mean ranged from 3.87 to 5.53mm with an average of 4.88 mm, indicating a 14.1% reduction due to heat stress. As for F_1 crosses, main stem diameter ranged from 4.97 to 6.27 mm with an average of 5.66 for 1st Sowing date and from 4.37 to 5.33 mm with an average of 4.86 mm for the late sowing date, indicating a 14.2 % reduction due to heat stress. The average reduction in main stem diameter over parents and F_1's due to heat stress was 14.2%.

Table (2): The means of main stem diameter (mm) of the 8 parents and their 28 F_1 hybrids in favorable environment, F (upper values) and heat stress environments, H (lower values).

Parents		P1	P2	P3	P4	P5	P6	P7	P8	Array mean
P1	**F**	5.33	5.30	5.73	5.53	5.10	5.13	5.27	6.27	5.46
	H	4.40	4.40	4.93	4.67	4.57	4.47	5.00	4.90	4.67
P2	**F**		5.87	6.27	5.97	5.63	5.17	5.90	6.07	5.77
	F		5.17	5.00	5.23	5.10	4.63	4.93	5.33	4.97
P3	**F**			6.63	6.20	5.67	5.47	6.27	6.17	6.05
	H			5.53	5.10	5.03	4.53	4.87	4.97	5.00
P4	**F**				5.93	5.90	5.00	5.57	6.07	5.69
	H				5.27	5.27	4.67	4.70	5.23	5.02
P5	**F**					5.03	5.13	5.63	5.73	5.48
	H					4.47	4.37	5.07	4.80	4.84
P6	**F**						4.57	4.97	5.43	5.11
	H						3.87	4.50	4.63	4.46
P7	**F**							5.9	6.13	5.71
	H							4.80	5.07	4.87
P8	**F**								6.20	6.01
	H								5.53	5.06

The analysis of variance revealed highly significant entries mean square indicating the existence of considerable differences among genotypes. The diallel of analysis of main stem diameter revealed the presence of significant additive and non-additive mean squares in normal environment and heat stress. The Wr/Vr graphical analysis is presented in Fig. 2. The slope of the regression line was significantly deviating from zero but not from unity (b=1.01+0.218and b=1.440+0.279) for 1st and 2nd sowing date, respectively). Over-dominance was operating under favorable condition ($\sqrt{H_1/D} > 1$) while dominance was partial under heat stress ($\sqrt{H_1/D} < 1$), indicating an additive-dominance model of gene effects. The genetic components of variation in main stem diameter are presented in Table 3. The additive genetic component (D) was smaller than the dominance parameter (H_1) for 1st sowing date, but the reverse was true under heat stress of 2nd sowing date. The narrow-sense heritability of main stem diameter was high being 0.78 and 0.62 for the 1st and 2nd sowing dates, respectively.



(a) (b)

Fig.(2): The Wr/Vr graph for stem diameter in favorable (a) and under heat stress environment (b)

Table (3): Components of the genetic variation for main stem diameter in favorable environment (F) and under heat stress (H).

Component	**Environments**	
	(F)	**(H)**
D	0.041 ± 0.019	0.332 ± 0.010
H_1	0.062 ± 0.044	0.126 ± 0.024
$\sqrt{H_1/D}$	1.230	0.616
N. heritability	0.776	0.618

2- Number of Vascular Bundles:

The Eight parental genotypes and the 28 F_1's exhibited variable expression of number of bundles in the wheat stem (Fig. 3 and Table 4). The mean of number of vascular bundles for parents ranged from 48.00 to 110.33 for the 1st sowing date with an average for 80.38 bundles, and from 47.67 to 91.00with an average of 75.58 for the 2^{nd} sowing , indicating 6.0 % reduction due to heat stress. The mean of F_1 crosses, ranged from 64.33 to 111.0 mm with an average of 82.84 bundles for 1^{st} Sowing date and from to 53.67 to 96.33 with average of 70.42 bundles for the late sowing date, indicating a 15.0% reduction due to heat stress. The average reduction in number of vascular bundles over parents and F_1's due to heat stress was10.5 %.

Table (4): The means of number of vascular bundles in wheat plant stem of the 8 parents and their 28 F_1 hybrids in favorable environment, F (upper values) and under heat stress environments (lower values).

Parents		P1	P2	P3	P4	P5	P6	P7	P8	Array mean
P1	F	81.67	85.67	103.33	80.33	76.00	64.33	83.33	82.00	82.08
	H	78.00	77.00	76.00	66.00	62.67	58.00	69.67	80.67	71.00
P2	F		84.00	92.67	78.00	85.33	64.00	84.67	101.33	84.42
	F		83.00	81.33	76.67	78.00	63.67	71.0	76.00	75.92
P3	F			110.33	91.00	87.67	88.00	95.00	98.67	95.58
	H			91.00	78.00	75.33	54.00	69.33	96.33	77.67
P4	F				80.33	77.67	65.00	66.33	111.00	81.21
	H				75.33	70.33	61.67	66.00	79.67	71.71
P5	F					77.00	63.67	79.00	86.67	79.13
	H					72.33	67.33	64.00	63.00	69.12
P6	F						48.00	65.00	73.67	66.46
	H						47.00	53.67	62.33	58.54
P7	F							74.00	91.33	79.83
	H							70.00	74.00	67.21
P8	F								88.00	91.58
	H								86.67	77.33

* calculated from interaction for Table.

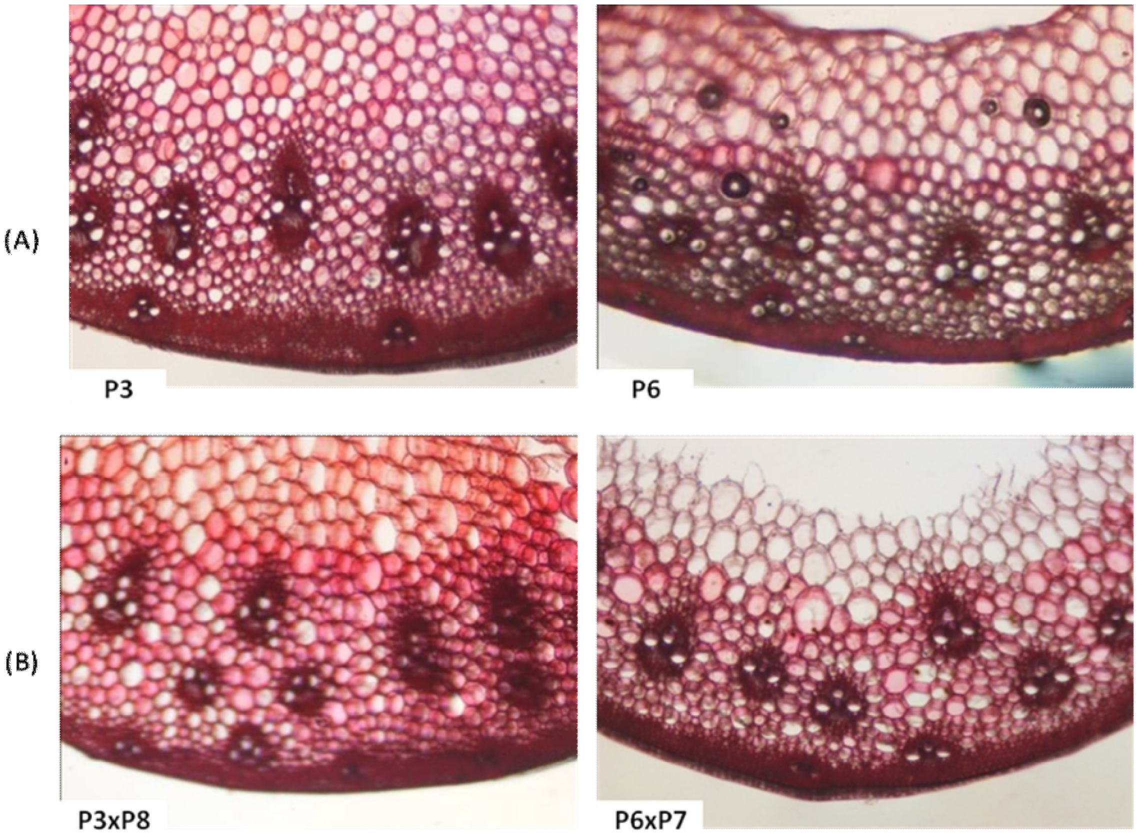
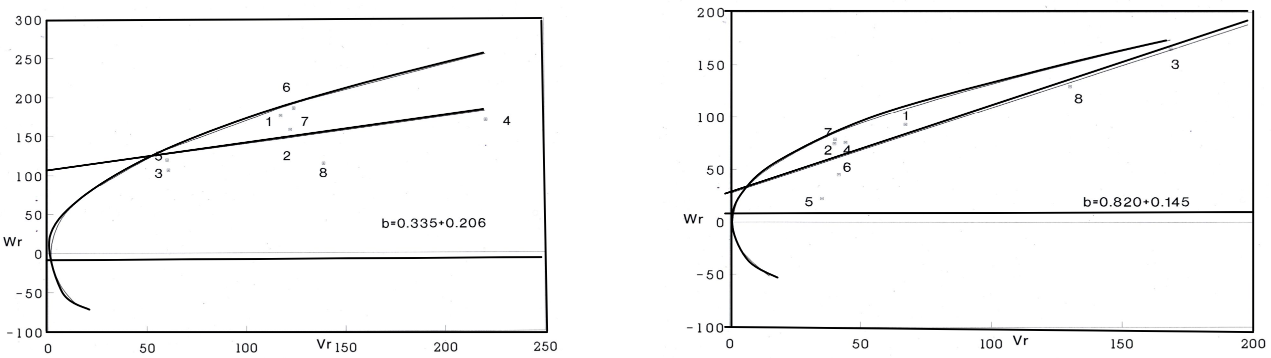


Fig.(3): Photo micrograph of vascular bundles of the stem in some parental genotypes (a) and (b) F_1,s crosses.

The analysis of variance revealed highly significant difference between genotypes as well as between environments. The diallel analysis revealed highly significant additive and non-additive mean squares. Non–allelic gene interaction was operating in the favorable environment. The slope of Wr/Vr regression line of 1st sowing date was not significantly deviating from zero (b = 0.335 ± 0.206) indicating the failure of the assumption of additive-dominance model, while the slope of Wr/Vr regression (Fig.4) under heat stress of 2nd sowing date was significantly deviating from zero but not from unity, indicating the adequacy of additive-dominance model. The genetic components of variation in number of vascular bundles are presented in Table 5. The additive (D) genetic component was greater in magnitude than dominance (H_1) components in the two sowing dates. The narrow-sense heritability estimate was high being 0.781 and 0.731 in the 1stsnd 2nd sowing dates, respectively.



(a) (b)

Fig.(4): The Wr/Vr graph for number of vascular bundles in favorable (a) and heat stress environment (b)

Table (5): Components of the genetic variation for number of vascular bundles in favorable environment (F) and under heat stress (H).

Component	Environments*	
	(F)	(H)
D	290.884 ± 4.292	173.275 ± 5.175
H_1	175.281 ± 9.667	105.251 ± 11.900
$\sqrt{H_1/D}$	0.776	0.779
N. heritability	0.781	0.732

3- 1000 Kernel Weight:

The mean of 1000 kernel weight of the eight parents and their 28 crosses are presented in Table 6. The parental means ranged from 35.2 to 55.5 g with an average of 46.1 g for 1st sowing date and from 27.7 to 47.9 g with an average 35.6 g for the 2nd sowing date. The reduction in the parental average due to heat stress was

22.8 %.The mean of F_1 crosses ranged from 45.2 to 56.5 g for 1st sowing date with average of 50.6 g and from 34.4 to 50.2 with average of 39.7 g for 2nd sowing date, indicating 21.5 % reduction in 1000 kernel weight. The range reduction over parents over plants and F_1's due to hear stress 22.2%.

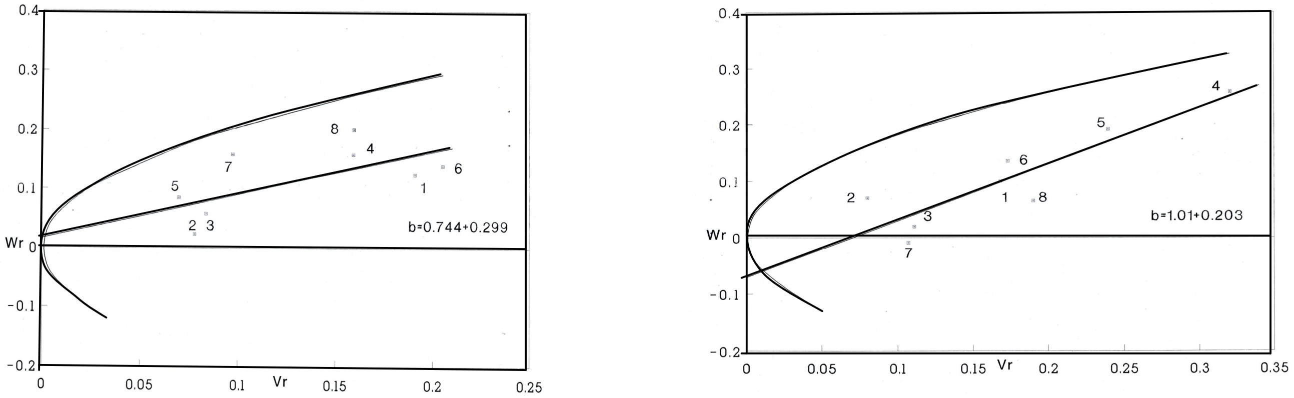
Table (6): The means of 1000 kernel weight (g) of the 8 parents and their F_1 hybrids in favorable environment, F (upper values) and under Heat stress environment (lower values).

Parents		P1	P2	P3	P4	P5	P6	P7	P8	Array mean
P1	F	38.80	48.88	45.55	51.11	51.19	49.93	48.85	48.88	47.77
	H	28.82	36.68	39.98	40.03	40.08	40.00	37.78	39.93	37.79
P2	F		49.92	55.57	50.08	49.94	47.50	50.00	46.40	49.97
	F		37.40	42.22	40.06	40.09	36.64	33.38	39.96	38.84
P3	F			48.60	55.54	53.31	49.91	55.54	50.07	52.27
	H			40.02	47.79	44.47	39.96	37.75	40.07	41.15
P4	F				46.68	49.95	47.79	52.28	56.65	50.07
	H				36.68	39.95	34.44	43.32	50.02	41.16
P5	F					47.70	46.60	51.19	52.27	51.14
	H					33.35	34.47	43.31	46.68	40.05
P6	F						35.52	45.52	45.54	45.57
	H						27.77	36.67	40.09	36.62
P7	F							48.83	5.04	50.03
	H							36.63	37.77	35.86
P8	F								55.55	52.21
	H								44.48	42.24

An analysis of variance revealed highly significant differences between the entries of the diallel cable as well as between environments indicating the existence of considerable variation among genotypes.

Graphical analysis of Wr/Vr relationship (Fig. 5) for both sowing dates, slowed that slope of the regression line was significantly deviating from zero but not from unity (b =0.774 +0.299 and b = 1.010 + 0.203 for 1st and 2nd sowing date respectively), indicating the adequacy of an additive-dominance model. The Wr/Vr regression line cut the Wr axis near the point of origin for 1st sowing date, indicating almost complete dominance, while the intercept was negative under heat stress of the 2nd sowing date, indicating over-dominance.

The genetic components of variation in 1000 kernel weigh are presented in Table 7. The additive (D) genetic component was smaller than the dominance parameter (H_1) for the two sowing date. The $\sqrt{H_1/D}$ value was 1.063 and 1.346 for 1st and 2ndsowing dates, respectively, indicating complete to over-dominance. The narrow-sense heritability estimate was 0.478 and 0.422 for 1st and 2ndsowing dates, respectively.



(a) **(b)**

Fig.(5): The Wr/Vr graph for 1000kernel weight in favorable (a) and under heat stress environment (b)

Table (7): Components of genetic variation for 1000 kernel weight in favorable environment (F) and under heat Stress (H).

Component	Environments	
	(F)	(H)
D	0.414 ± 0.012	0.323 ± 0.029
H_1	0.468 ± 0.028	0.585 ± 0.052
$\sqrt{H_1/D}$	1.063	1.346
N. heritability	0.478	0.402

4 – Grain yield per spike:

The yield of Grain yield per spike of eight parents and their 28 hybrids are presented in Table 8. The parental average of 5.51 to 2.50 g with an average of 3.33g for 1st sowing and from 2.35 to 1.12 g with an average of 1.98 g for 2nd sowing date. The reduction in the parental average due to heat stress was 40.54%. The mean of F_1 crosses ranged from 3.93 to 2.45 g with an average of 3.26 g and from 3.36 to 1.23 g with an average of 2.07 g for 2nd sowing date, indicating 36.50% reduction due to heat stress. The average reduction in Grain yield per spike due to heat stress was 38.5%.

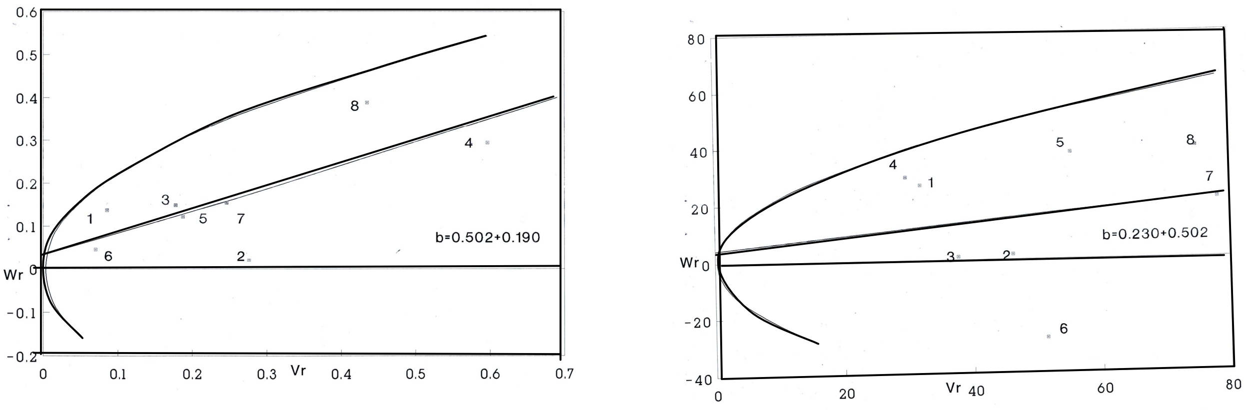
Table (8): The means of grain yield per spike (g) of the 8 parents and their F1 hybrids in favorable environment, F (upper values) and under Heat stress environments (lower values).

Parents		P1	P2	P3	P4	P5	P6	P7	P8	Array mean
P1	F	2.84	3.30	2.49	3.63	2.27	3.30	2.64	3.73	3.03
	H	1.78	2.93	1.79	2.08	1.75	2.32	2.30	2.46	2.10
P2	F		3.31	3.80	3.92	3.84	2.75	3.19	3.54	3.46
	F		1.81	1.93	3.41	2.49	1.83	2.30	2.04	2.21
P3	F			3.12	3.92	3.17	2.80	3.18	2.67	3.14
	H			1.55	2.65	1.23	1.52	1.58	1.86	1.76
P4	F				5.51	4.21	3.02	3.52	3.93	3.96
	H				2.35	1.66	1.83	1.29	3.36	2.33
P5	F					2.75	3.67	2.88	3.05	3.23
	H					1.12	1.78	1.97	1.93	1.74
P6	F						2.53	2.45	3.40	2.99
	H						1.86	1.47	1.96	1.82
P7	F							2.50	3.58	2.99
	H							1.87	2.77	1.94
P8	F								4.31	3.53
	H								3.50	2.52

*calculated from interaction – free diallel Table.

An analysis of Variances revealed highly significant differences between genotypes and between environments. The Wr/Vr graphical analysis (Fig. 6) revealed that the slope of the regression line was significantly deviating from zero but not from unity for 1st sowing date ($b = 0.502 \pm 0.190$), indicating partial dominance but in the 2nd sowing date was not significant deviating from zero ($b = 0.230 \pm 0.502$) indicating the failure of the assumption of an additive-dominance model and the possible non allelic interaction involvement.

The components of the genetic variation in grain yield per spike are presented in Table 9. The additive (D) genetic component was smaller in magnitude than (H_1) component in both sowing dates, the narrow –sense heritability estimate was 0.445 and 0.328 in the 1st and 2nd sowing dates, respectively.



(a) **(b)**

Fig.(6): The Wr/Vr graph for 1000kernel weight in favorable (a) and under heat stress environment (b)

Table (9): Components of genetic variation in grain yield per spike in favorable environment (F) and under heat stress (H).

Component	Environments	
	(F)	(H)*
D	0.466 ± 0.042	47.758 ± 9.546
H_1	0.797 ± 0.090	178.512 ± 21.945
$\sqrt{H_1/D}$	1.308	1.9.33
N. heritability	0.478	0.4328

Phenotypic correlation among parents and F_1 hybrids.

For parents and F_1's stem diameter was positively correlated with number of vascular bundles in the two environments (Table 10). Stem diameter was positively correlated with 1000 kernel weight in the two environments while number of vascular bundles showed significant association with 1000 kernel weight only under favorable conditions. The two Stem attributes were significantly correlated with grain yield per spike.

Table (10): phenotypic correlation between stem diameter attributes and yield components in favorable (upper values) and heat stress (lower vales) environments.

Character		No. Vascular bundles	1000 kernel weight	Grain yield per spike
Main stem diameter	**F**	0.770**	0.592**	0.472**
	H	0.687**	0.593**	0.419**
No. Vascular bundles	**F**		0.534**	0.472**
	H		0.290	0.419**
1000 kernel weight	**F**			0.279
	H			0.356

Phenotypic correlation among F_2 segregates under heat stress.

Stem diameter displayed significant positive correlation with 1000 kernel weight under heat stress in the 9 F_2 (Table 11) and with grain yield per spike in six populations.

Table (11): Phenotypic correlation between main stem diameter and yield component (1000 kernel weight, grain yield per spike) in F_2 segregation under heat stress.

No	Cross	Plant number	1000 kernel weight	Grain yield per spike
1	1 × 2	200	0.322**	0.240*
2	2 × 3	200	0.295**	0.287*
3	3 × 4	200	0.427**	0.191
4	1 × 6	200	0.428**	0.346**
5	3 × 6	131	0.447**	0.431**
6	4 × 6	200	0.304**	0.272**
7	1 × 8	200	0.505**	0.495**
8	3 × 8	167	0.340**	0.127
9	4 × 8	146	0.218*	0.107

Distribution of stem diameter under heat stress

The distribution of segregates of the 9 F_2 populations for stem diameter under heat stress indicated their the almost normal shape of the histograms and the continuous nature of that character revealing the polygenic nature of the genes controlling it. Transgressive segregation was evident in the 9 F_2's indicating that the genes controlling this character were highly dispersed among the parents involved.

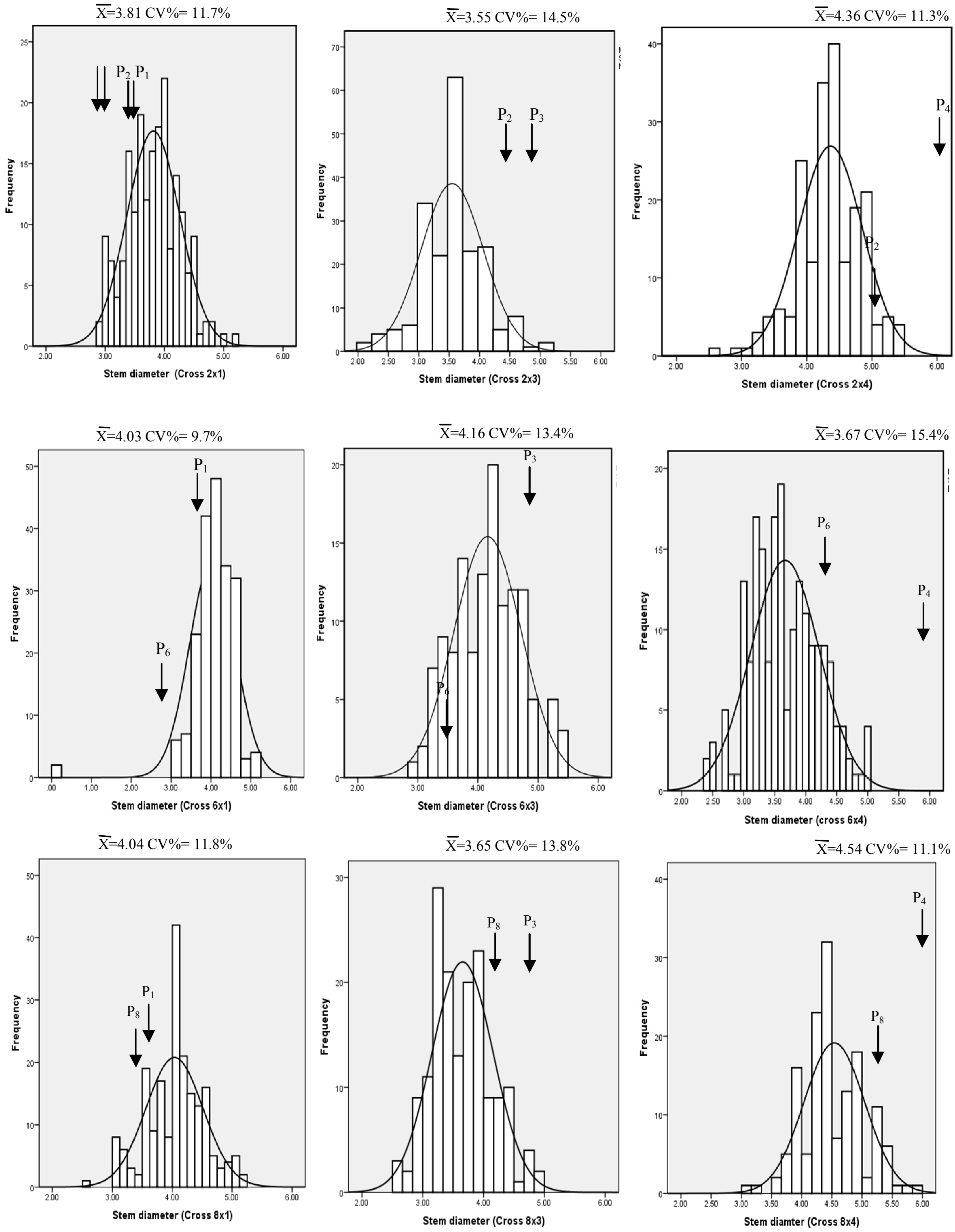


Fig.(7): Distribution of F_2 segregates for diameter of main stem under heat stress condition

Discussion:

Highly significant positive correlation was established between stem diameter (a morphological trait) and number of vascular bundles (anatomical trait) in favorable environment (r=0.69, p<0.01) and under heat stress (r=0.77, p<0.01). Evidently, a considerable proportioned of variation observed at the external phonotypic level (ear diameter) is ascribed to that displayed at the internal phonotypic level (number of vascular bundles in the stem). Apparently, the two stem attributes were similarly almost equal average reductions (14.1 % in stem diameter and 10.7 in number of vascular bundles). The observation put together would indicate that the two traits are developmentally related and are less affected by heat stress than grain yield per spike 38.5% average reduction) or 1000 kernel weight (22.2% average reduction).The reductions observed in this study in stem diameter due to heat stress was greater than the 6 % average reduction reported by (Wardlaw, 2002 and Sallam *et al.,* 2014). Similarly, the reductions in grain yield per spike and 1000 kernel weight were greater in the present study (38.5% and 22.2%, respectively) than those respected by (Sallam *et al*., 2014) which amounted to 17% and 8.8%, respectively. Such reductions in stem attributes as well as in yield components under heat stress might have resulted from accelerated phasic development (Warrington *et al.,* 1977 and Frank and Boner, 1987), increase in respiration (Berry and Bjorkman, 1980) reduction in photosynthesis (Blum, 1986 and Conroy et al, 1994) and inhibition of starch synthesis in developing kernels (Gent, 1994). As the results of this study have indicated the two attributes were quantitatively inherited traits which were controlled by genes with additive-dominance effects under heat stress. The additive genetic variance was reported to be predominating over/non-additive for stem diameter in wheat (Yao *et al*., 2012 and Sallam *et al.,* 2014). The narrow-since heritability estimates were reasonably high for the two stem traits under heat stress (h^2 =0.76 for ear diameter and 0.68 for number of vascular bundles). Evidently, the two traits could be genetically manipulated through selection. Directional phonotypic relation is feasible and practical since this character is easily scorable in earl segregating generations at preanthasis stage. In creasing stem diameter would increase the storage capacity of the stem for assimilates that are formed before anthesis and are to be trans located to the developing kernels after anthesis under heat stress (Gent, 1994 ; Blum *et al*, 1994). According to (Ehdaie *et al.* 2006b) itrenode length, iternode weight and internode specific weight of the stem of the wheat plant affect the accumulation and mobilization of stem reserved with maximum specific weight being correlated with stem mobilized dry mater. The significant positive associations observed in this study under heat stress between stem diameter and grain yield per spike (r= 0.42, p<0.01) as well as with 1000 kernel weight (r= 0.59, p<0.01) lend a further support to that relationship which was also reported by (Sallam *et al.,* 2014) in wheat under drought and heat stresses as well as by (Salih *et al.,* 2014) in maize under drought stress. Since the actual site for soluble carbohydrates storage in the stem is the phloem of the vascular bundles, the significant positive associations between its number and grain yield per spike under heat stress (r= 0.42, p<0.01) was expected. Since a stem diameter and number of v ascular bundles were both correlated and associated with yielding ability under heat stress, selection for ear diameter would produce positive correlated response in number of bundles in the stem and consequently greater storage capacity for assimilates which contribute to greater grain yield under stress.

References:

Berry, J. and O.B.; Bjorkman (1980). Photosynthetic response and adaptations to temperature in higher plants. Ann Res. Plant Physiol., 31: 491–532.

Blum, A. (1986). The effect of heat stress on wheat leaf and spike yield in Anstralia: a physiological frame work. J. Agric. Res., 29: 89-91.

Blum, A.; B. Sinmena; J. Mayer; G. Golan and L. Shpiler (1994). Stem reserve mobilization Supports wheat-grain filing under heat stress. Australian Journal of Plant Physiology. 21: 771 – 781.

Conroy, J.P.; S. Senewera; A.S. Basra; G. Rogers and B. Nissem-Wooler (1994). Influence of rising atmospheric CO_2 concentration and temperature on growth yield and grain quality of cereal crops. Aust. J. Plant Physiol., 20: 741-758.

Ehdaie, B.; G.A. Alloush; M.A. Madore and J.G. Waines (2006a). Genotypic variation for stem reserves and mobilization in wheat: I. Postanthesis changes in Internode dry matter. Crop Sci. 46:735 -746.

Ehdaie, B., G.A. Alloush; M.A. Madore and J.G. Waines (2006b). Genotypic variation for stem reserves and mobilization in wheat: II. Postanthesis changes in internode water-soluble carbohydrates. Crop Sci., 46: 2093–2103.

Frank, A.A. and A. Boner (1987). Temperature effects prior to double ridge on apex development and phyllochron in spring barley. Crop Sci., 37: 1527-1531.

Gent, M.P.N. (1994). Photosynthate reserves during grain filling in winter wheat. Agron., J., 86: 159–167.

Gent, M.P.N. and R.K. Kiyomoto (1985). Comparison of canopy and flag leaf net carbon dioxide exchange of 1920 and 1977 New York winter wheats. Crop Sci., 25: 81–86.

Hayman, B.I. (1954a). The analysis of variance of diallel tables. Biometrics 10: 235–244.

Hayman, B.I. (1954b). The theory and analysis of variance of diallel crosses. Biometrics. 39: 789–809.

McCullough, D.E. and L.A. Hunt (1989). Respiration and dry matter accumulation around the time of anthesis in field stands of winter wheat (*Triticum aestivum* L.). Ann. Bot., 63: 321–329.

Rawson, H.M. and L.T. Evans (1983). The contribution of stem reserves to grain development in a range of wheat cultivars of different height. Aust. J. Agric. Res. 22: 851-863.

Salih,A.I.S.: A.A. Abdelmula,: E.M.A.Bashir,: S. Khan, : S. Ying,: Y.Yang,; S.U. Baloch, ; W. Bashir (2014). Genetic

Variation of Plant Height and Stem Diameter Traits in Maize (*Zea mays* L.) under Drought Stress at Different Growth Stages. Journal of Natural Scinces Resarch,4 (23):116-122

Sallam, A.; E. Hamed; M. Hashad and M. Omara (2014). Inheritance of stem diameter and its relationship to heat and drought tolerance in wheat (*Triticum astivum L.*). J. Plant Breed. Crop Sci., 6 (1): 11- 23

Wardlaw, I.F. (2002). Interaction between drought and chronic high temperature during kernel filling in wheat in a controlled environment. Annals Bot., 90: 469-476.

Wardlaw, I.F. and C.W. Wrigley (1994). Heat tolerance in temperature cereals: an overview. Aust. J. Plant Physiol., 21: 695–703.

Wardlaw, I.F. and J. Willenbrink (2000). Mobilization of fructanuy reserves and changes in enzyme activities in wheat stems correlate with water stress during kernel filling. New Phytologist. 148:413-422.

Warrington, L.J.; R.L. Dunstone and L.M. Green (1977). Temperature effects on three developmental stages on the yield of the wheat ear. Aust. J. Agric. Res. 28: 11-27.

Yao, J. ; X. Yang, ; M. Zaho, ; D. Yang, ; H. Ma (2012) Inheritance of grain yield and its correlation with yield components in bread wheat (*Triticum astivium* L.) Turkish J. Field Crops 19(2): 169-174.

تحكم التباين الوراثي في قطر ساق وعدد الحزم الوعائية وعلاقتها بمحصول الحبوب فى قمح الخبز تحت الإجهاد الحراري

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الملخص:

تم تحليل النظام الوراثي المتحكم في قطر الساق وعدد الحزم الوعائية وغيرها من الصفات المحصولية للقمح (*Triticum astivium* L.) في تلقيح نصف دائري لثمانية إباء ، اختيرت تحت الظروف المواتية وظروف الحرارة ، ودرست قطاعات تشريحية للسلامية الثانية في الساق في الآباء و الجيل الأول وتم عد الخزم من خلالها ، كما درست الأنعزالات في ٩ عشائر جيل ثاني تحت الإجهاد الحراري، وجد ان البوليجينات ذات الآثار المضيفة تتحكم في صفة قطر الساق والتى اطهرت انعزالا في توزيعات طبيعية في الجيل الثاني وكانت درجة توريث صفة قطر الساق متقاربة تحت البيئة المواتية (٠,٧٨) وبيئة الإجهاد الحراري (٠,٦٢) وكذلك عدد الحزم الوعائية تحت البيئة المواتية (٠,٧٨) وبيئة الإجهاد الحراري (٠,٧٣) ، كما تبين وجود تلازم معنوي بين قطر الساق و عدد الحزم الوعائية وكلا من وزن الألف حبة ومحصول حبوب السنبلة فتى البيئتين ، وتلك التلازمات تحت ظروف الإجهاد تشير إلى الدور الهام الذى تلعبه صفة قطر الساق في تعضيد مليء الحبوب بتوفير قدرة أختزانية اكبر لنواتج التمثيل الضوئى بالساق قبل تحريكها إلى الحبوب.