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Relationships between Stomatal Conductance and Yield Components in Spring Durum Wheat under Mediterranean Conditions

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Abstract

The objective of this study was to determine relationships between stomatal conductance and yield components. Field trials were conducted at Field Crops Department Research Area, Agricultural Faculty, University of Cukurova during the 2000-2001 growing season in a completely randomized blocks design with three replications. The measurements of stomatal conductance (g_s) were made at three stages (early milk, late milk and early dough maturity). Stomatal conductance showed statistically differences among genotypes. Genotypes showed differences for all agronomical traits assessed. Stomatal conductance had positive correlations with grain yield, grain numbers per spike, spike yield, and spike length at early stage. Results are discussed in terms of the possibilities of g_s to be a criteria in wheat breeding at Cukurova Region.

Keywords: drought tolerance, wheat, yield components

Introduction

Stomatal conductance (g_s) is known for its relevance to drought tolerance. Shimshi and Ephrat (1975) showed positive correlations among grain yield, photosynthesis rate, and stomatal conductance (g_s) in dwarf spring wheat under irrigation conditions. Stomatal conductance can change with short term changes of photosynthetically active radiation and temperature (Squire & Black, 1981). It also changes with seasonal and daily differences of plant water relations depending on genotype (Jones, 1977; Roark and Quisenberry, 1977). Reliable measurements of g_s require dry and clear air conditions. The number of replications and subsamples has to be increased (Jones, 1987). Fischer *et al.* (1977) have reported that g_s measurement needs 10 samples for each block and application in wheat, in addition sample numbers must be increased under water stress conditions. Although measurement of total leaf conductance is a possible method, researchers generally take samplesfrom the leaf surface (Gay, 1986; Bennet *et al.,* 1987). Delgado *et al.* (1994) have reported that positive relations between g_s and yield in bread wheat have been found; but these relations are not clear in durum wheat. Also, these relations as well as g_s values decrease during the last growth period (Rees *et al.,* 1993; Delgado *et al.,* 1994). Koc *et al.* (2001) have shown that these relations change with the nitrogen amount in bread wheat under Mediterranean conditions. One of the most popular methods which determines stomatal conductance among wheat genotypes is measure of Canopy Temperature Depression (CTD). Canopy Temperature Depression values of durum wheat (0.63 to 1.23°C.) was found higher than in bread wheat (-0.22 to 0.57°C). Thus, durum wheat genotypes can keep more cooler than bread wheat (Bahar *et al.*, 2008). Some research results show that this situation was based on the higher g_s values of durum wheat genotypes (Bahar, 2004).

The aim of this study is to determine the relations between g_s and yield components in high yielding durum wheat genotypes in the Mediterranean Region. Furthermore, the physiological basis of the yield differences will be understood more easily by the use of g_s as selection criteria.

Materials and methods

Field trials were conducted at Field Crops Department Research Area (Latitude: 41°04′N, Longitude: 36°71′E, and Altitude: 36m), Agricultural Faculty, University of Cukurova, during the 2000-2001 growing season. Trial design was a completely randomized block with three replications. Twenty two durum wheat lines and 3 durum wheat cultivars were used as material. Sowing was done with a plot drill (Hege-80) on December 2, 2000. Trial plots had six square meter area (with 5 m x 1.2 m sizes), and 450 seeds were planted per square meter. All of phosphorus (80 kg ha^{-1}, P_2O_5) and half of total nitrogen (80 kg ha^{-1}, N) was applied at sowing time. The other half of the N was split and given at tillering (as urea) and booting (as ammonium nitrate) stages respectively. Weeds were controlled by hand collecting. No-irrigation were applied during growth season. The trial was harvested at the first week of June, 2001 at physiological maturity with a Hege-125 trial harvester machine.

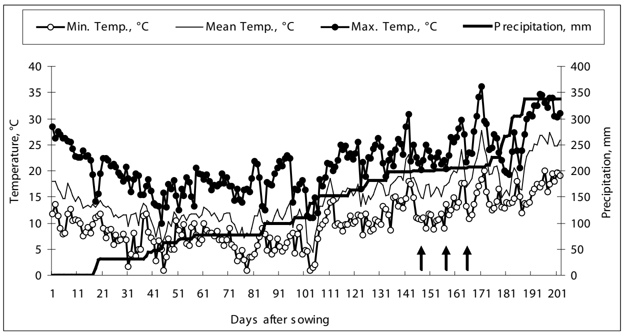

Fig. 1. Daily minimum, mean, maximum temperature and cumulative precipitations during growing season, arrows indicate, ZGS:73, 78 and 83 respectively. (Source: Meteorology Regional Headship Reports, Adana, Turkey)

Temperature and precipitations (338 mm seasonal total) are given in Fig. 1.

Stomatal conductance (g_s) was measured by diffusion porometer (AP4-Delta-T Eijelkampt, Giesbech, The Netherlands) on flag leaf top surface as mmol H_2O m^{-2} s^{-1}. Measurements were made at three periods according to Zadoks Growth Scale (Zadoks *et al.*, 1974) (early milky maturity, ZGS:73; late milky maturity, ZGS:77; early dough maturity, ZGS:83) at full clear air conditions between 10:00 am and 16:00 pm, about 1500 PAR light intensity and 40 percent relative humidity.

Variance analysis and multiple comparisons of data with Duncan Multiple Range Test, and correlations among characters were made by MSTAT-C (1989).

Results and discussion

Agronomical traits are listed in Tab. 1., stomatal conductance values at the different stages are shown in Fig. 2.,

Tab. 1. Avarage Values of Agronomical Traits in Spring Durum Wheat Genotypes

Name of the Cultivar or Breeding Line	Grain yield (kg ha^{-1})	Plant height (cm)	Thousand grain weight (g)	Spike yield (g spike^{-1})	Grain no. per spike (no spike^{-1})	Spike length (cm)	Spikelet no. per spike (no spike^{-1})
Gediz-75	4020 ced*	99.0 e-h	43.2 c-h	2.08 c-f	48.0 b-f	8.20 b-e	21.4 abc
Balcali-2000	5530 abc	108.3 c	53.1 abc	2.78 abc	52.0 b-e	6.97 f-i	19.5 bcd
Amanos-97	4780 a-d	102.3 c-g	46.9 a-g	2.02 c-f	42.9 c-f	6.50 hi	18.7 cd
Bagan-5	3650 de	127.3 a	49.4 a-e	2.08c-f	41.7 def	6.57 hi	19.2 bcd
Strian-4	3640 a-e	118.7 b	50.6 a-e	1.92 def	37.5 f	5.80 i	18.5 d
Lgt 1//Khbl/	4430 b-e	97.7 e-h	42.5 e-h	2.04 c-f	47.9 b-f	7.30 d-h	19.3 bcd
NN90 E3-14 (MOR)/	4080 cde	86.3 i	37.5 gh	1.52 f	40.3 ef	6.77 hi	18.7 cd
Altar 84/Stn//	4340 b-e	107.0 cd	41.8 e-h	1.99 c-f	47.0 b-f	7.47 c-h	20.6 a-d
Auk/Guil//Green	5270 abc	97.0 e-h	43.9 b-h	2.13 b-f	48.2 b-f	6.80 ghi	19.3 bcd
Dipper2/Bushen3	4890 a-d	98.7 e-h	44.8 b-h	1.91 def	42.5 c-f	7.00 e-h	20.2 a-d
Dipper2/Bushen3	4920 a-d	107.3 c	45.4 b-h	2.18 a-f	46.8 b-f	7.10 e-h	18.7 cd
Gonrin/Gudrols	5440 abc	102.3 c-g	42.7 d-h	1.69 ef	40.2 ef	7.67 c-h	20.4 a-d
Green38/Bushen4	5730 ab	94.7 gh	43.9 b-h	2.27 a-f	51.2 b-e	7.27 d-h	19.3 bcd
Plata7/Fillo9	5130 a-d	98.0 e-h	43.5 c-h	2.55 a-d	58.4 ab	8.57 bc	20.6 a-d
Porron4/Yuanl	4980 a-d	95.3 gh	38.9 fgh	2.59 a-d	66.9 a	8.13 b-f	20.1 a-d
Rascon37/Tarro	5320 abc	95.7 fgh	36.7 h	2.20 a-f	59.6 ab	10.03 a	21.8 ab
Rascon39/Tilol	6220 a	103.7 c-f	43.3 c-h	2.09 c-f	48.4 b-f	7.60 c-h	18.9 cd
Srn3/Ajaial5	4750 a-d	92.7 hi	41.5 e-h	2.18 a-f	54.9 a-d	9.07 ab	21.7 ab
Suokupko7	5630 abc	99.3 d-h	53.4 ab	2.95 ab	55.0 a-d	8.20 b-e	20.2 a-d
Zehong2NO	5870 ab	104.0 cde	52.4 a-d	3.00 a	55.3 abc	8.00 b-g	21.3 ad
Sebah	3110e	118.7 b	48.0 a-f	2.27 a-f	46.8 b-f	6.47 hi	19.4 bcd
Arthur71/Bcr	4340 b-e	122.0 ab	55.4 a	2.51 a-e	45.0 c-f	6.70 hi	19.3 bcd
Bcrch-1	4060 cde	101.0 c-g	43.7 b-h	2.07 c-f	47.4 b-f	8.37 bcd	22.4 a
Quassel 1-14	4680 a-e	95.7 fgh	55.8 a	2.40 a-e	42.9 c-f	7.50 c-h	20.9 a-d
Bicre	4570 b-e	99.0 e-h	48.6 a-f	2.38 a-e	49.0 b-f	7.47 c-h	19.9 a-d
Avarage	4780	102.9	45.9	2.23	48.6	7.50	20.0
LSD0.05	333.3	6.809	8.184	0.695	11.08	1.01	2.3
CV (%)	6.85	4.03	10.87	18.97	13.88	8.22	7.0
Min	3117	86.3	36.7	1.52	37.5	5.8	18.5
Max	6220	127.3	55.8	3.0	66.9	10.0	22.4

* : Values in the same group are not different according to the significance level of 0.05 %.

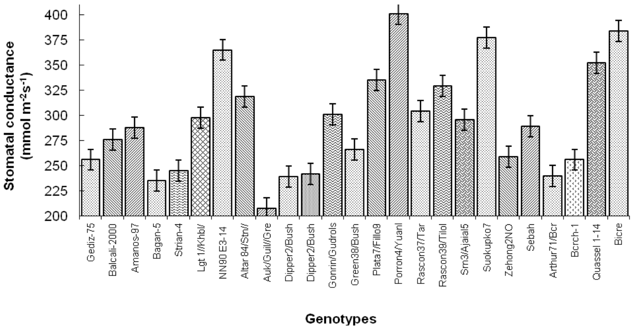

Fig. 2. Stomatal Conductance Values of Genotypes at Early Milky Maturity Period. Vertical bars indicate ± SE of mean. Data significant at P = 0.05

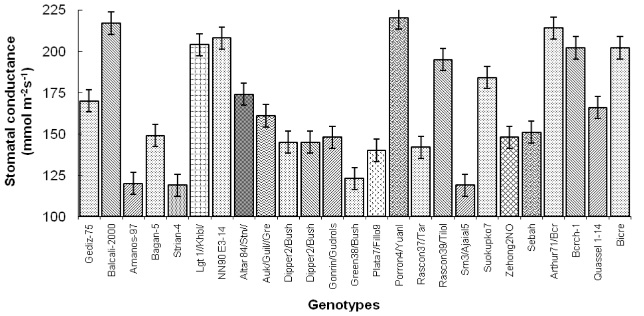

Fig. 4. Stomatal Conductance Values of Genotypes at Early Dough Maturity Period. Vertical bars indicate ± SE of mean. Data significant at P = 0.05

3. and 4. The genotypes showed significant differences for the evaluated agronomical traits.

According to the Figs., average gs measures of all genotypes at early milky, late milky and early dough maturity periods were 294, 225 and 167 mmol H_2O m^{-2} s^{-1}, respectively. When g_s values were evaluated for each measurement period, at early milk period, g_s was found high in Porron 4/Yuan1 durum wheat line (401 mmol H_2O m^{-2} s^{-1}), and the lowest value was found in Auk/Guil//Green (208 mmol H_2O m^{-2} s^{-1}). At late milky period, g_s was found highest in NN-90-E3-14 (MOR) (366 mmol H_2O m^{-2} s^{-1}), lowest in Altar-84/Stn// (128 mmol H_2O m^{-2} s^{-1}). At early dough maturity period, statistical differences among genotypes for g_s were not significant, however, g_s values ranged

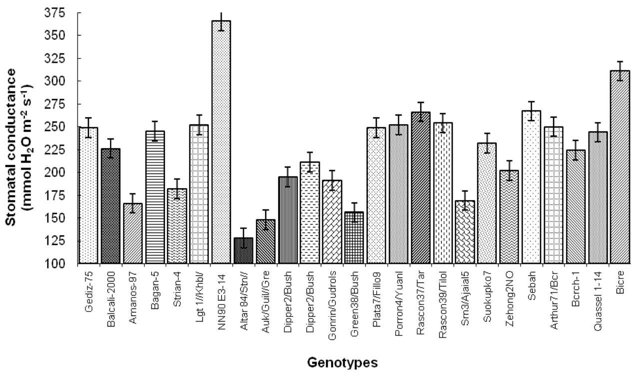

Fig. 3. Stomatal Conductance Values of Genotypes at Late Milky Maturity Period. Vertical bars indicate ± SE of mean. Data significant at P = 0.05.

from 119 (Srn3/Ajaia 15) to 220 mmol H_2O m^{-2} s^{-1} (Porron 4/Yuan1). g_s values decreased at later growth periods, and these results are supported by the findings of Rees *et al.* (1993) and Bahar (2004).

Relationships between g_s and grain yield were found positive (but non-significant) at early milky period (r = 0.165) and negative non-significant at late milky maturity period (r = -0.234), while they were not found correlations at early dough maturity period. It has been reported that because of leaf senescence at the growth periods, yield-g_s relations have been increased; also, durum wheats have shown some differences to bread wheat for this relation (Rees *et al.,* 1993; Delgado *et al.,* 1994).

When the relationships of g_s with yield components and agronomic traits have been evaluated, it has been found a positive significant correlation between g_s and grain numbers per spike (r = 0.392*),a positive non significant correlation between g_s and spike yield (r = 0.184), and positive significant correlation between g_s and spike length (r = 0.331*) at early milky maturity period. Also, between g_s and plant height, negative correlations were found both for early milky (r = -0.468*) and late milky maturity periods(r = -0.114). Fischer *et al.* (1981) have reported hard negative relationship between plant height and g_s.

If the genotypes are classified according to their phenologies at anthesis as earlier (19 genotypes) and later group (6 genotypes) and relations between g_s and yield components were evaluated, positive significant relations between g_s and grain numbers per spike (r = 0.503*) were observed at only milky maturity period in the earlier group. However, there were no statistically significant positive correlations between g_s and grain yield (r = 0.421, P>0.072), or for g_s and spike length (r = 0.443, P>0.057). Stomatal conductance and plant height showed a negative non-significant correlation at the earlier group (r = -0.428, P>0.068) at early milky maturity period. At the later group, genotypes showed negative significant correlation (r = - 0.851*) at late milky maturity.

Conclusions

At grain filling period, although there has been found a relationship between g_s of genotypes and grain numbers per spike and spike length at early milky maturity; g_s has been found negative relation with plant height, while it has not been found relation with g_s at late milky and early dough maturity periods.

When genotypes have been classified according to their phenologies at anthesis as earlier and later group; g_s values have shown positive correlations with grain yield and grain numbers per spike at early milky maturity period, in earlier genotypes. These correlations confirm the importance of grain formation for grain yield. With the later genotypes, at early and late milky maturity periods a highly significant negative correlation has been found between g_s and grain yield, and this correlation has shown that these genotypes have not effectively used the available water for yield.

In conclusion, if g_s is evaluated according to genotypes' phenologies, it was understood that g_s is a selection criteria in breeding programs.

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References

Anonymous, (2001). Monthly Weather Reports. Meteorology Regional Headship. Adana. Turkey.

Bahar, B. (2004). A research on relationships with stomatal conductance and the other leaf traits between grain yield and yield components in bread and durum wheat genotypes under Cukurova high- and low-land conditions. Faculty of Agriculture, University of Cukurova. Adana. PhD Thesis. p 157.

Bahar, B., M. Yildirim, C. Barutcular and I. Genc (2008). Effect of canopy temperature depression on grain yield and yield components in bread and durum wheat. Not. Bot. Hort. Agrobot. Cluj. 36(1):34-37.

Bennett, J. M., T. R. Sinclair, R. C. Muchow and S. R. Costello (1987). Dependence of stomatal conductance on leaf water potential, turgor potential, and relative water content in field-grown soybean and maize. Crop Sci. 27:984-990.

Delgado, M. I., M. P. Reynolds, A. Larque-saavedra and T. Nava , (1994). Mexico, Genetic diversity for photosynthesis in wheat under heat-stressed environments and its relationship to productivity. Wheat Special Report No. 30, Cimmyt, Mexico.

Fischer, R. A., F. Bidinger, J. R. Syme and P. C. Wall (1981). Leaf photosynthesis, leaf permeability, crop grovvth, and yield of short spring wheat genotypes under irrigation. Crop Sci. 21:367-373.

Fischer, R. A., M. Sanchez and J. R. Syme (1977). Pressure chamber and air flow porometer for rapid field indication of water status and stomatal conductance in wheat. Exp. Agric. 13:341-351.

Gay, A. P. (1986). Assessment of the response to selection for leaf water conductance in *Lolium perenne*. Annals of Botany 64:593-598.

Jones, H. G. (1977). Aspects of water relations of spring wheat *(Triticum aestivum* L.) in response to included drought. J. Agric. Sci. 88:267-282.

Jones, H. G. (1987). Breeding for stomatal characters, p. 432-443, In: E. Zeiger, G. D. Fraquhar and I. R. Cowan (Eds.). Stomatal function. Stanford Univ. Press. Stanford

Koc, M., C. Barutcular and I. Genc (2001). Association of stomatal sonductance and grain yield of bread wheat in Cukurova. 4th National field crops congres, Tekirdag, Turkey, 87-92.

Mstat, C. (1989). Mstat-C Software, Version 1.4. Crop and Soil Science Department, Michigan State University, East Lancing, MI.

Rees, D., K. D. Sayre, E. Acevedo, T. S. Nava , Z. Lu, E. Zeiger and A. Limon (1993). Mexico, Wheat Special Report No. 10, Canopy temperature of wheat: relationship with and yield and potential as a technique for early generation selection. Cimmyt.

Roark, B. and J. E. Quisenberry (1977). Environmental and genetic components of stomatal behaviour in two genotypes of uplond cotton. Plant Physiol. 59:354-356.

Shimshi, D. and J. Ephrat (1975). Stomal behaviour of wheat cultivars in relation to their transpiration, photosynthesis and yield. Agron. J. 67:326-331.

Squire, G. R. and J. R. Black (1981). Stomatal Behaviour in the Field, p. 223-245. In: P. I. Jarvis, T. A. Mansfield (Eds.). Stomatal Physiology. Cambridge Univ. Press, Cambridge.

Zadoks, J. C. and T. T. Chang (1974). A decimal code for growth stages of cereals. Weed Res. 14:415-421.