

## INFLUENCE OF WATER DEFICIT ON TRANSPIRATIONAL AND WATER RELATION PARAMETERS IN WHEAT

J.P. SRIVASTAVA AND S.N. CHATURVEDI

SKN College of Agriculture, Jobner-303 329

### ABSTRACT

Potted plants of wheat cv 'C-306' (drought resistant) and 'Kalyan sona' (relatively drought susceptible) were compared for various transpirational parameters under moisture stress. Differences in transpiration rates were narrower in the control and in stressed plants of 'C-306' than in 'Kalyan sona'. The difference of leaf to air temperature was higher in 'Kalyan sona'. Abaxial to adaxial leaf conductance ratio increased in both the varieties under severe stress condition. Correlations between various components of water relation and transpiration in the two cultivars are discussed.

### INTRODUCTION

Reduction in transpiration and leaf conductance in plants are well documented under conditions of water stress (Bradford and Hsiao, 1982). Abaxial and adaxial stomata respond differently to changes in environmental variables (Kanemasu and Tanner, 1969, Morgan, 1977 a), but significance of this factor in drought resistance of crops has not been much studied.

Leaf water potential (Singh and Singh, 1984) was found to be a good parameter to calculate plant water stress. Wheat genotypes expressing osmotic adjustment perform well under stress (Morgan, 1983). Uprety and Sirohi (1985) attributed better performance of wheat cv 'C-306' over 'Kalyan sona', under stress conditions, to its maintenance of higher leaf water potential. Therefore, experiments were conducted to study these parameters in drought resistant and relatively drought susceptible genotypes of wheat.

### MATERIAL AND METHODS

Experiments were carried out during rabi 1987-88 at SKN College of Agriculture, Jobner. Drought resistant wheat cv 'C-306' and relatively susceptible 'Kalyan sona' were grown in earthen pots (radius 20 cm dia x 22 cm depth) containing 10 kg of loamy soil (Bulk density  $1.48 \text{ g cm}^{-3}$ , field capacity 11.8 % and PWP 2.8%) under optimal cultural conditions. Fifty per cent of the pots of each variety were per-conditioned to stress to induce hardiness by giving three drought cycles : water

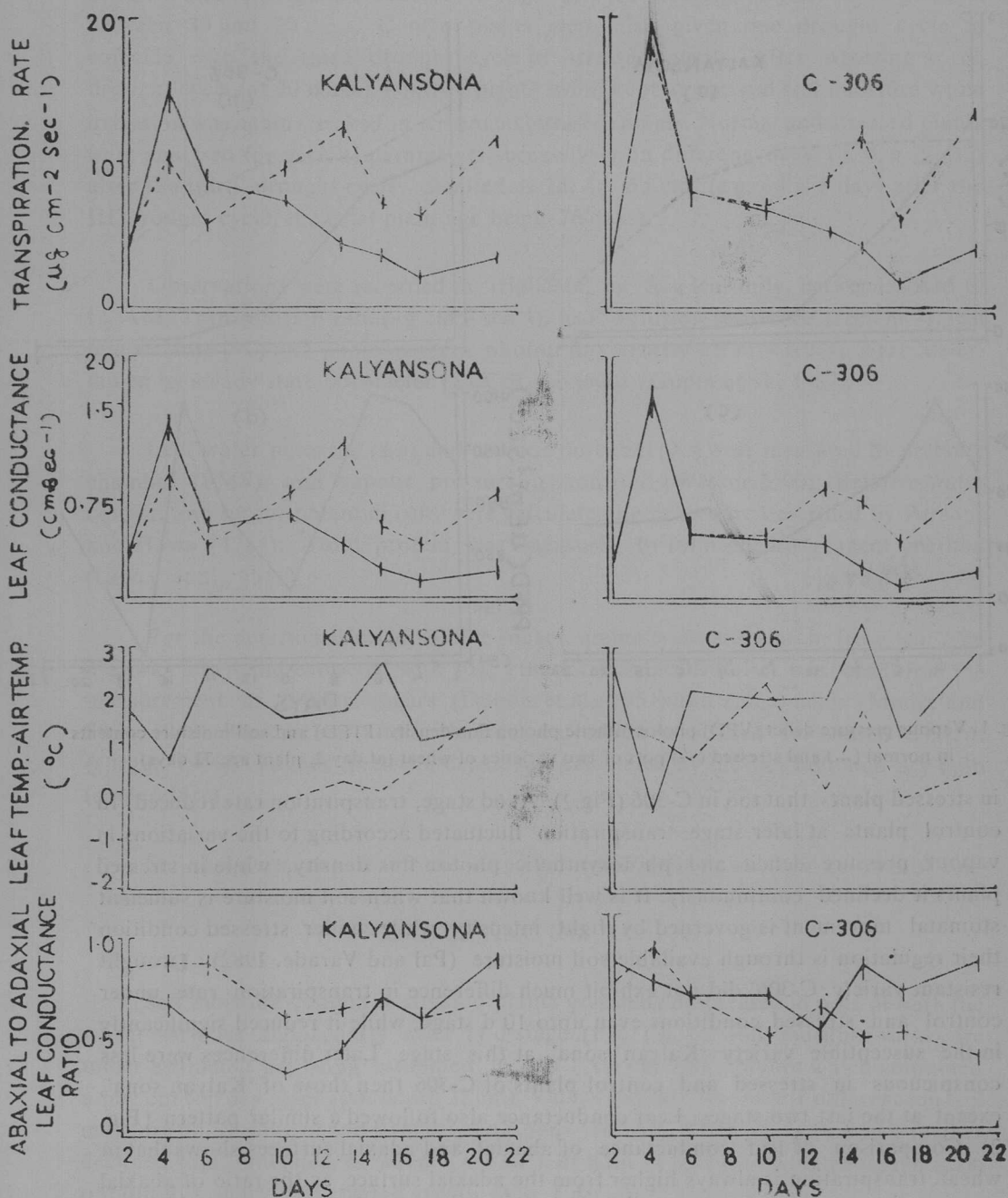


Fig. 2. Transpiration rate, leaf conductance, leaf to air temperature difference and abaxial ratio of conductance in two varieties of wheat under normal (.....) and stress (—) conditions (at day 2, plant age 72 days)

significantly in 'C-306'. However, when stress became more severe i.e. after 13 d stage, it increased. Observations indicate that water stress, even of mild intensity, causes the reduction in leaf conductance, preferentially of abaxial surface, in susceptible variety, while in the resistant one' abaxial conductance is affected more, that too, when stress is very severe. Lesser decrease in abaxial leaf conductance of 'Kalyan sona' than adaxial is probably due to preferential supply of water towards adaxial side. Such difference has been observed in sunflower (Aston, 1976). Differential osmotic adjustment in abaxial and abaxial stomata has also been given as cause of such behaviour of stomata in cotton (Brown et al., 1976).

Differences between leaf temperature and air temperature ( $T_l-T_a$ ) were significant. Leaves of control plants remained cooler than the leaves of the stressed plants (Fig. 2). Singh and Singh (1984) reported a difference of 5°C in  $T_l-T_a$  in wheat plants growing understress condition. In 'Kalyan sona', temperature of leaves of control plants was lower than the air except at the terminal stage while in 'C-306', it was at or above air temperature. Stressed plants almost always showed higher leaf temperature than the air. Water stress causes marked increase in leaf temperature, thus altering the physiological functions of leaf. 'Kalyan sona' plants appeared to be adapted to physiological activities at or below the air temperature. The situation was just reverse for 'C-306' where leaves appeared to be adapted to higher temperature.

Significant differences in relative water content were observed after 6 d in 'C-306' and after 11 d in 'Kalyan sona' (Fig. 3). The latter variety showed sudden decrease in relative water content after 11 d. Though both the varieties showed almost same extent of reduction in relative water content under stress condition, the difference between stressed and control plants was narrow in 'C-306'.

Water stress reduced the leaf water potential ( $\psi_w$ ) through, especially after 11 d stage. At 15 d stages, 'C-306' registered relatively higher  $\psi_w$  than 'Kalyan sona' under stress conditions.

Varietal differences were significant with respect to changes in osmotic potential ( $\psi_\pi$ ) under stress (Fig. 3 e, f) control plants of both varieties showed  $\psi_\pi$  between -2.33 MPa to -2.85 MPa, which are in accordance with the earlier reports (Morgan, 1977 b, 1983). As the water stress increased  $\psi_\pi$  of 'Kalyan sona' decreased. Degree of reduction increased, further after 11 d. While  $\psi_\pi$  of stress and control plants of C-306 did not differ significantly till 15 d, followed by a sharp decline. In 'Kalyan sona' osmotic constituents appeared to increase from very beginning while in 'C-306' accumulation appeared at a faster rate only under severe stress conditions. Major osmotic constituents responsible for decrease in  $\psi_\pi$  are increased levels of soluble sugars and amino acids/organic acids accompanied with change in potassium (Jones et al., 1980, Ford and Wilson, 1981). Changes in the levels of sugars, amino acids

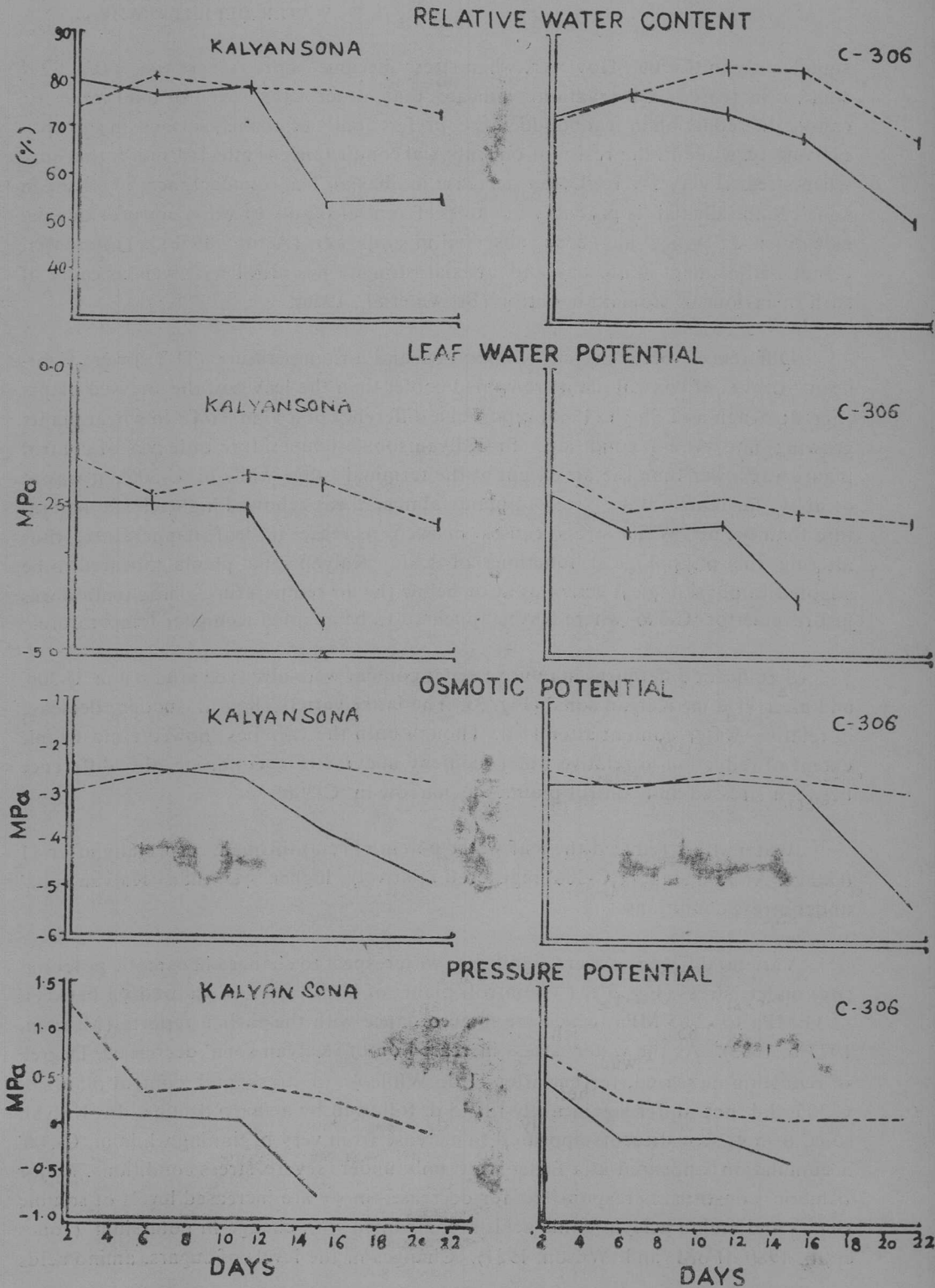


Fig. 3. Changes in various components of water relation under normal (.....) and moisture stress (—) conditions in two varieties of wheat (days indicate the days after release of third cycle of stress).

and soluble proteins of these varieties were observed at last two stages when water stress was severe. At 15 d soluble sugar level of stressed 'Kalyan sona' plants reduced significantly (Table 1). The trend was same at 21 d stage as well. Amino acid level of stressed plants also showed significant increase. In 'C-306' only free amino acids accumulated under stress conditions while soluble sugars did not differ significantly in control and stress plants at both the observation stages. Non-significant reduction in soluble sugars and higher levels of amino acids might contribute to lower  $\psi\pi$  in C-306 under stress condition. Starch and soluble proteins, though do not constitute as osmoticum, but their levels may indicate the synthesis the utilization patterns. Starch content of both the genotypes either did not differ significantly (15d stage) or increased significantly (21d stage) suggesting its probable suppressed utilization. Protein level did not show significant change due to stress in both the varieties except at 15 d stage in 'C-306' where it reduced. Normal levels of soluble sugar under stress in 'C-306' also indicate less reduction in photosynthetic rate of 'C-306' in comparison to 'Kalyan sona' as reported also by Uprety and Sirohi (1985).

Table 1. Levels of soluble sugars, starch, amino acids and soluble proteins (mg g fresh weight) in wheat varieties under control and stressed conditions at 16 days and 21 days after III drought cycle

	Stage			
	15 d stage (+ SE)		21 d stage (+ SE)	
	Control	Stressed	Control	Stressed
<b>Kalyan sona</b>				
Soluble sugars	48.99±6.6	35.53±1.6	37.77±1.7	27.97±6.1
Starch	4.14±0.5	3.95±0.5	9.70±1.5	14.71±0.3
Amino acids	1.69±0.2	2.34±0.2	1.88±0.1	2.95±0.2
Soluble proteins	9.93±1.6	9.48±3.0	13.88±0.9	13.16±0.2
<b>C-306</b>				
Soluble sugars	32.59±0.1	37.81±4.1	26.95±4.7	24.5±1.4
Starch	5.26±0.1	5.77±1.2	10.97±0.6	19.08±4.6
Amino acids	1.59±0.2	2.03±0.1	1.50±0.3	3.65±0.2
Soluble proteins	15.51±2.2	10.85±1.8	12.76±3.1	14.29±0.2

Turgor potential ( $\psi\rho$ ) was not measured directly but derived from  $\psi\omega$  and  $\psi\pi$  values, therefore, residual errors are compounded with this parameter (Parsons and Howe, 1984). Initially, under control conditions, 'Kalyan sona' showed very high value of  $\psi\rho$  (1.28 MPa) as compared to C-306 (0.77 MPa Fig. 3). But latter on it remained almost same in both the varieties (around 0.3 MPa) except at the terminal stage. 'Kalyan sona' it remained positive upto 11 d then declined sharply while in 'C-306' reduction was prominent between 2 d and 6 d followed

by very slow reduction. Difference in  $\psi\rho$  of normal and stressed plants of 'C-306' was narrow as compared to 'Kalyan sona'.

Our observations indicate that lesser reduction in transpiration rate, narrow difference in leaf to air temperature, maintenance of adaxial transpiration rate over abaxial, lower  $\psi\pi$ , lesser reduction in  $\psi\omega$  and  $\psi\rho$  enables C-306 to tolerate the moisture stress.

Based on these observations significant positive correlation was obtained between RWC and various components of water relation and transpiration like  $\psi\omega$ , transpiration rate and leaf conductance (Table 2) under stress condition. Under control condition these correlations were not significant. Transpiration rates and leaf conductance are also positively correlated with  $\psi\omega$  and  $\psi\pi$  though more positively with  $\psi\pi$ . Correlation between (Tl-Ta) and transpiration was not significant but when individual varieties were analysed, 'C-306' showed significantly negative correlation ( $r = -0.73$ ). In 'Kalyan sona' though negative but non-significant correlation was recorded. It may be concluded that Tl-Ta may be taken into account for screening drought resistant wheat genotypes.

Table 2. Correlation coefficient (r) between various components of water relation and transpiration in wheat varieties under stress condition

	Tranpiration rate	Leaf conductance	Difference in leaf and air temperature (Tl-Ta)	Relative water content	
W	0.97	0.55	0.51	-0.22	0.87
S		0.77	0.69	-0.26	0.93
Transpiration rate			0.98	0.05	0.71
Leaf conductance				-0.55	0.71
Difference in leaf and air temperature (Tl-Ta)					-0.28

#### ACKNOWLEDGEMENTS

Authors are grateful to Dean, SKN College of Agriculture, Jobner and Director Research, Rajasthan Agriculture University, Bikaner for providing necessary facilities.

#### REFERENCES

- Aston, M.J. 1976. Variation of stomatal diffusive resistance with ambient humidity in sunflower (*Helianthus annuus*). Australian Journal of Plant Physiology. 3:489-50.
- Bradford, K.J. and Hsiao, T.C. 1982. Physiological response to moderate water stress. In: Encyclopedia of plant physiology, New series, Vol. 12 B (O.L. Lange,

- P.S. Nobel, C.B. Osmond and H. Ziegler eds). pp. 263-324, Springer-Verlag, Berlin.
- Brown, K.W., Jordan, W.R. and Thomas, J. 1976. Water stress induced alternations of the stomatal response to decrease in leaf water potential. *Physiologia Plantarum*, 37: 1-15.
- Clegg, M.K. 1956. The application of anthrone reagent to the estimation of starch in cereals. *Journal of Science, Food and Agriculture*. 7: 40-44.
- Dubois, M. Gilles, K., Hamilton, J.K. Robers, P.A. and Smith, F. 1951. A colorimetric method for determination of sugars. *Nature*, 168: 167.
- Ford, C.W. and Wilson, J.R. 1981. Changes in levels of solutes during osmotic adjustment to water stress in leaves of four tropical pasture species. *Australian Journal of Plant Physiology*. 8 : 77-91.
- Gupta, S.C.; Lal, P., Muralia, R.N., Kumar, A. and Srivastava, J.P. 1987. Effect of soil salinity and alkalinity on morpho-physiological parameters of pearl millet. *Annals of Arid Zone*. 26: 25-32.
- Jones, M.M., Osmond, C.B. and Turner, N.C. 1980. Accumulation of solutes in leaves of sorghum and sunflower in response to water deficit. *Australian Journal of Plant Physiology*. 7: 193-205.
- Kanemasu, E.T. and Tanner, C.B. 1969. Stomatal diffusion resistance of snap beans. I. Influence of water potential. *Plant Physiology*. 44 : 1547-1552.
- Lawry, O.H., Resebrough, N.J., Fan, A.L. and Randal, R.J. 1951. Protein measurement with the folin-phenol reagent. *Journal of Biological Chemistry*. 193: 265-275.
- Moore, S and Stein, W.H. 1984. Photometric method for use in chromatography of amino acids. *Journal of Biological Chemistry*. 176: 367-388.
- Morgan, J.M. 1977a. Changes in diffusive conductance and water potential of wheat plants before after anthesis. *Australian Journal of Plant Physiology*. 4: 75-86.
- Morgan, J.M. 1977b. Differences in osmoregulation between wheat genotypes. *Nature*. 270: 234-235.
- Morgan, J.M. 1983. Osmoregulation as selection criterion for drought tolerance in wheat. *Australian Journal of Agricultural Research*. 34: 607-614.
- Pal, D. and Varade, S.B. 1982. Studies on energy status and transpiration of wheat plants as influenced by aerial environment, soil water potential and texture. *Indian Journal of Plant Physiology*. 25: 201-212.
- Parsons, L.R. and Howe, T.K. 1984. Effect of water stress on water relations of *Phaseolus vulgaris* and drought resistant *Phaseolus aconitifolius*. *Physiologia Plantarum*. 60: 197-202.

- Rawson, M.M., Giffara, R.M. and Bremner, P.M. 1976. Carbon dioxide exchange in relation to sink demand in wheat. *Plants*. 132: 19-23.
- Singh, V.P. and Singh, M. 1984. Relation between canopy minus air temperature and leaf water potential in field grown wheat. *Indian Journal of Plant Physiology*. 27: 20-25.
- Upreti, D.C. and Sirohi, G.S. 1985. Effect of water stress on photosynthesis and water relations of wheat varieties. *Indian Journal of Plant Physiology*. 28: 107-114.