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# Physiological response of wheat (*Triticum durum* L.) to limited irrigation

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## ABSTRACT

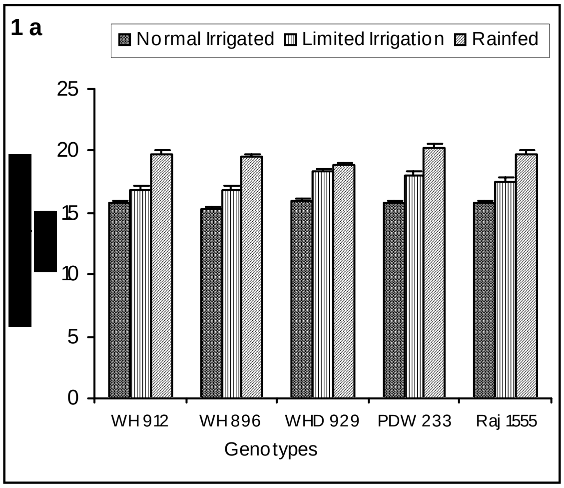
A field study was conducted at CCS Haryana Agricultural University, Hisar, during two consecutive *rabi* seasons of 2002-03 and 2003-04 on wheat genotypes. The main plots treatment consisted of three irrigation schedules viz., normal irrigation (Control), two irrigations at 45 and 85 DAS (limited irrigation) and no post sowing irrigation (rainfed) and in sub-plots five genotypes were grown namely WH 896, WH 912, WHD 935, WHD 936, PDW 233, Raj 1555. The restricted irrigation decreased the leaf water potential (LWP), canopy temperature depression (CTD), transpiration rate, stomatal conductance and photosynthesis significantly over irrigated control, while, significant increase was observed in plant water retention. Reduction in grain yield under rainfed condition was 23.4 per cent. Reduced irrigation application decreased the yield attributes with maximum reduction in number of grains per spike. Genotype PDW 233 yielded significantly higher than all other tested genotypes. It maintained higher plant water status and higher rate of photosynthesis than other genotypes.

***Key words:*** Canopy temperature depression, photosynthesis, stomatal conductance, wheat.

Water is one of the most important inputs influencing yield of field crops. The present water supply for crop production is bound to decrease in near future with increasing demand of water for drinking and industrial purposes. Hence, the food crop like wheat, highly susceptible to moisture stress due to its higher water requirement, is likely to suffer most. On the other hand, unscientific water management i.e. excessive irrigation by flooding without drainage facility has led to rise in water table, which is seen around 6-7 m ha area in India. There is lot of scope to reduce the numbers of irrigation by judicious water management through capillary rise from ground water (Pannu *et al*., 2002). Selection of suitable crop variety is one of the ways for obtaining higher yield and as well as to get higher water use efficiency. Among the wheat, durum wheat has higher genetic drought tolerance and its water requirement is lower than bread wheat (El-Hafid *et al*., 1998). Hence the present experiment was conducted to find out suitable genotype of durum wheat for higher yield with limited numbers of irrigation under shallow water table condition.

## MATERIAL AND METHODS

A field experiment was conducted on durum wheat (*Triticum durum* L) during two consecutive *rabi* seasons of 2002-03 and 2003-04 at Crop Physiology Research Area of Agronomy Research Farm, CCS Haryana Agricultural University, Hisar ($29^o$-10'N latitude, $75^o$-46' E longitude and 215 m altitude), India. The treatments consisted of three schedules of irrigation in main plot viz., normal irrigation (control) i.e. four irrigations at 22, 45, 85 and 105 DAS; two irrigations at 45 and 85 DAS (limited irrigation) and no post-sowing irrigation (rainfed) and five genotypes in sub-plot namely WH 896, WH 912, WHD 935, WHD 936, PDW 233 and Raj 1555 . The available soil moisture was 13.8 cm in 1.0 m profile. The experiment was laid out in split plot design with three replications. A common pre-sowing irrigation of 7.0 cm depth was applied 15 days before sowing in the experimental field to obtain a uniform crop stand. The crop was sown in the first week of November in rows with 22.5 cm spacing under shallow water table condition (< 2.0 m). The soil of the field was sandy loam in texture, low in organic carbon (0.38 %), alkaline in reaction (pH 8.0) and medium in fertility (146 kg $ha^{-1}$ available N, 21.5 kg $ha^{-1}$ available $P_2O_5$ and 476 kg $ha^{-1}$ available $K_2O$). All other agronomical practices were followed as per recommended package of practices. The rainfall received during the crop season was 25.5 mm (10 rainy days) and 38.6 mm (5 rainy days) during 2002-03 and



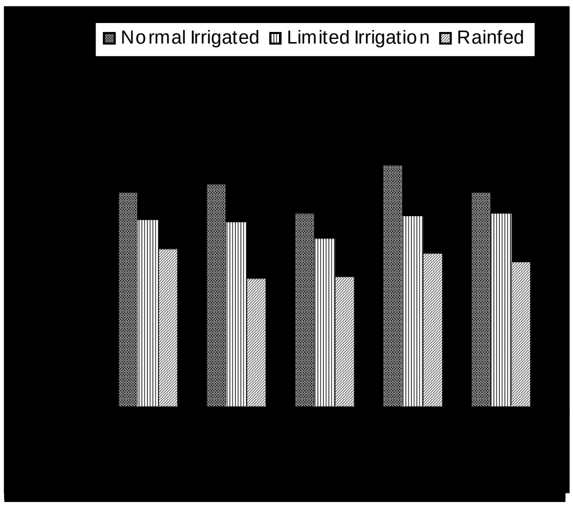




**Fig. 1.:** Effect of irrigations and genotypes on (a) leaf water potential, (b) canopy temperature depression, (c) water retention, (d) transpiration rate, (e) stomatal conductance and (f) photosynthetic rate of durum wheat

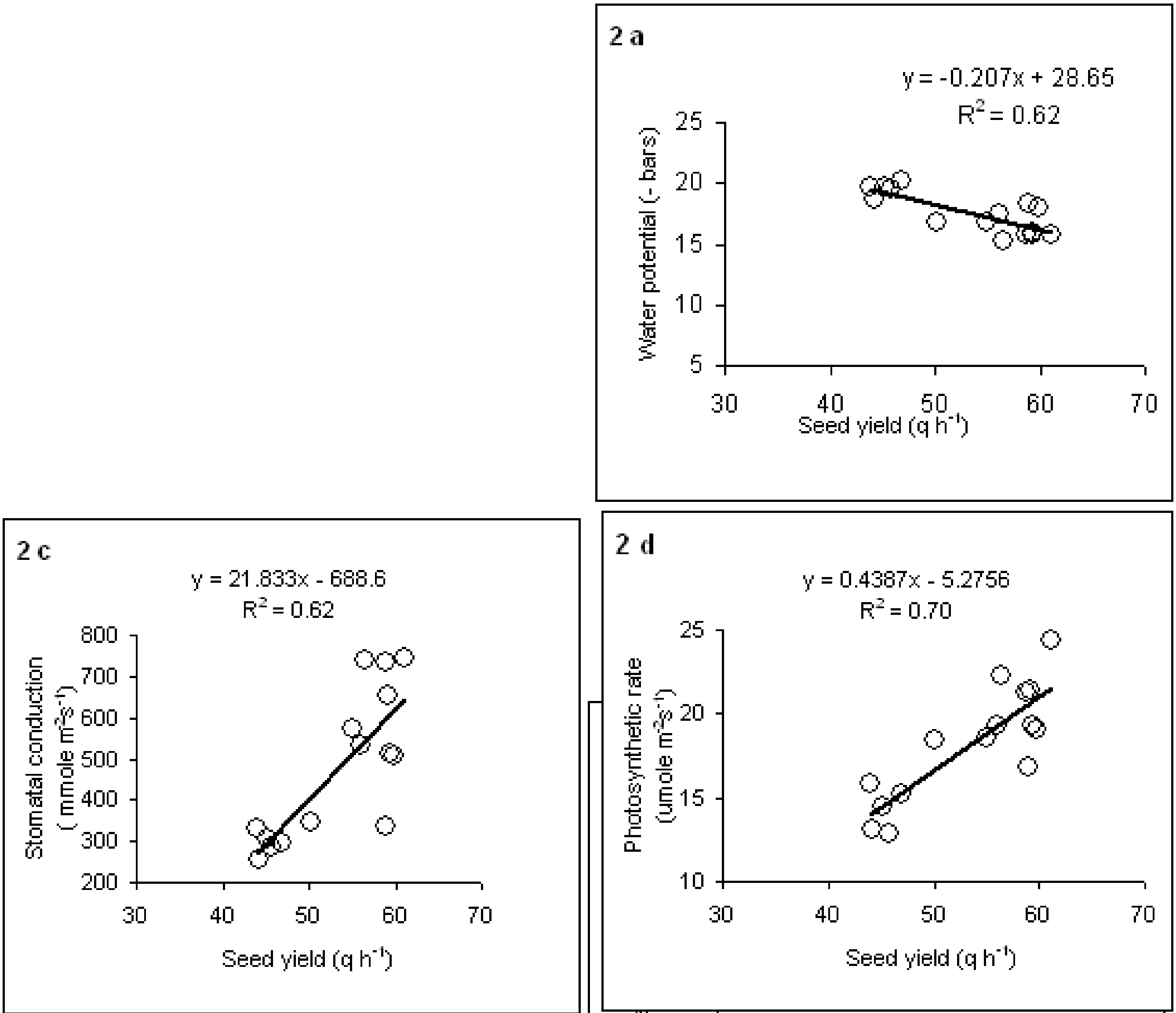



**Fig. 2.:** The relationship between seed yield and (a) leaf water potential, (b) transpiration rate, (c) stomatal conductance and (d) photosynthetic rate of durum wheat

2003-04, respectively. The plant water relation parameters were recorded at anthesis stage (95 - 100 DAS) between 1200 to 1400 h. The leaf water potential ($\Psi_w$) was measured by Pressure Chamber (PMS Instrument Co., Oregon, USA), water retention was computed from the fresh weight of each tiller sample (weighed after six hours shade drying at constant room temperature and oven dry weight at 65 $^0$C after 48 hours) following Dedio (1975). Transpirational cooling *i.e.* canopy temperature depression (CTD) was measured by using Infra-red thermometer (Model AG-42 Tela-temp Corp.CA). The photosynthetic rate was measured on flag leaf using Infra-red Gas Analyzer (IRGA, CIRAS-1, PP Systems, UK.). The measurements were made on the portion of leaves exposed directly to sunlight between 1100 to 1200 h. on five plants in random in each plot. Data presented are mean of four sets of measurements. At the same time, stomatal conductance and transpiration were determined with IRGA. The yield attributes were recorded on sample

**Table 1:** Effect of irrigation schedules and genotypes on yield attributes and yield of durum wheat (pooled of two years).

| Treatments | Plant height (cm) | Effective tillers/plant | Spike length (cm) | Spikelets/ spike | Grains/ spike | Test wt (g) | Grain yield (kg $h^{-1}$) | Biological yield (kg $h^{-1}$) | HI (%) |
|---|---|---|---|---|---|---|---|---|---|
| **Irrigation schedule** | | | | | | | | | |
| Normal irrigation | 101.1 | 4.4 | 7.2 | 19.2 | 48.1 | 42.6 | 5899 | 14646 | 40.3 |
| Limited Irrigation | 97.8 | 4.0 | 6.7 | 18.3 | 43.7 | 39.7 | 5541 | 14280 | 38.8 |
| Rainfed | 92.8 | 3.5 | 6.3 | 16.8 | 39.1 | 35.8 | 4520 | 13266 | 34.1 |
| CD at 5 % (p=0.05) | 1.2 | 1.3 | 0.6 | 0.8 | 1.9 | 2.3 | 621 | 1113 | 2.1 |
| **Genotypes** | | | | | | | | | |
| WH 912 | 94.3 | 4.1 | 6.8 | 18.3 | 44.9 | 37.9 | 5256 | 14427 | 36.3 |
| WH 896 | 98.6 | 3.8 | 6.5 | 17.6 | 43.8 | 37.8 | 5080 | 13132 | 38.6 |
| WHD 929 | 97.5 | 3.8 | 6.8 | 18.2 | 40.9 | 39.6 | 5351 | 14321 | 37.2 |
| PDW 233 | 99.0 | 4.0 | 7.0 | 18.2 | 43.9 | 42.1 | 5563 | 14694 | 37.8 |
| Raj 1555 | 96.8 | 4.1 | 6.7 | 17.9 | 45.7 | 39.7 | 5350 | 13746 | 38.8 |
| CD at 5 % (p=0.05) | 2.0 | NS | NS | NS | 1.8 | 2.1 | 205 | 816 | 1.2 |

of five plants from each plot. Grain yield was recorded from the individual net plot and expressed in kg $h^{-1}$. The results of experiment were pooled and analyzed following Panse and Sukhatme (1985).

## RESULTS AND DISCUSSION

The crop wheat responds to irrigation application significantly even under shallow water table condition (Table 1). The high grain yield of 4520 Kg $ha^{-1}$ obtained under rainfed condition with a harvest index of 34.1 % with meager amount of seasonal rainfall was due to ground water contribution under shallow water table depth of less than two meters. Dhindwal *et al*. (1994) and Ibrahim (1999) also reported 30-50 % ground water contribution to wheat raised under shallow water table condition. While limited irrigations (2 irrigations at 45 and 85 DAS) showed reduced grain yield of durum wheat by 5 percent. Withdrawal of post-sowing irrigation reduced the yield by 25.6 percent. Similar results were reported in wheat by Pannu and Sharma (2004). The increase in grain yield was 22.6 and 30.5 % over no irrigation treatment with application of two (45 and 85 DAS) and four irrigations (22, 45, 85 and 105 DAS) showing significant association between grain and biological yield ($r^2 = 0.68$). This emphasized that rainfed crop has significantly lower plant height, tillering, number of grains per spike and test weight (Pannu and Sharma, 2004). Post-sowing irrigation (both treatments) invariably brought about significant improvement in all these characters.

The perusal of data (mean of 2 years) given in the Fig. 1 revealed that restricting irrigations decreased the leaf water potential (Fig. 1a), canopy temperature depression (Fig. 1b), transpiration rate (Fig. 1d), stomatal conductance (Fig. 1e) and photosynthesis (Fig. 1f) significantly over irrigated control. While, plant water retention (Fig. 1c) found significantly higher with increase in soil moisture deficit. Reynolds *et al* (2000) reported that carbon uptake is dependent to a large extent on the stomatal conductance which was measured at the same time as that of photosynthesis. The per cent decrease in LWP, CTD, transpiration rate, stomatal conductance and photosynthesis under two irrigations over normal irrigated control was 11.1, 28.0, 10.7, and 32.1 and 15.1 percent, respectively. Whereas, in the corresponding decrease in the above physiological traits was 24.8, 40.9, 25.6, 56.6 and 34.3 percent, respectively under no post sowing irrigation. However, plant water retention increased 10.8 and 17.8 percent with two irrigations and no post sowing irrigation respectively. Siddique *et al* 2001 also reported similar decrease in plant water status under drought stress. In fact, grain yield had positive significant linear association with LWP, transpiration rate, stomatal conductance and photosynthesis (Fig. 2a-d) with limited and no post sowing irrigation.

The highest grain yield was seen with cultivar PDW 233 followed by WHD 929, Raj 1555 and it was the lowest in WH 896. The grain yield of PDW 233 was significantly higher than all other tested genotypes. Cultivar PDW 233 showed higher plant water potential (LWP), maintaining cooler canopy (CTD) and higher water retention capacity than other genotypes with higher rate of photosynthesis and stomatal conductance over other tested genotypes. The interaction between irrigation levels and genotype was non-significant because all the genotypes were highly responsive to irrigation with comparable potential yield.

## REFERENCES

Dedio, W. (1975). Water relations in wheat leaves as screening test for drought resistance. *Canadian J. Plant Sci.*, **55**: 369-378.

Dhindwal, A.S., Singh, J. and Poonia, S.R. (1994). Productivity, profitability and water use of cropping system under shallow water table in a semi-arid climate. *Proc.* Workshop on Integrated Development of Irrigated Agriculture. Central Board of Irrigation and power, New Delhi. pp.271-283.

El- Hafid, R., Smith, D. H., Karrou, M. and Samir, K. (1998). Morphological attributes associated with early season drought tolerance in spring durum wheat. *Euphytica,* 101 (3): 273-282.

Ibrahim, S.M. (1999). Wheat cultivation under limited irrigation and high water table condition. *Egyptian J. Soil Sci.,* 39**:** 361-372.

Pannu, R. K., Singh, D. P., Tyagi, P. K., Sharma K. D. and Chaudhary, B. D. (2002). Response of wheat genotypes to limited irrigation under late sowing and shallow water table conditions. In: *2nd Intern. Agron. Congress*, New Delhi. pp. 1289-1291.

Pannu, R. K. and Sharma K. D. (2004). Selection of wheat genotypes for limited irrigation under shallow water table conditions. *Haryana J. Agron.* 20 (1): 59-61.

Panse, V.C. and Sukhatme, P.V. (1985). Statistical methods for agricultural research workers. ICAR, New Delhi.

Reynolds, M. P., Singh, R.P., Ibrahim, A., Ageeb, O.A.A., Larque- saavedra, A. and Quick, J.S. (1998). Evaluating physiological traits to complement empirical selection for wheat in warm environments. *Euphytica,* 100: 85-94.

Reynolds, M. P., Delgado, M.I., Rodriguez, M.G. and Larque-saavedra, A. (2000). Photosynthesis of wheat in a warm, irrigated environment. I: Genetic diversity and crop productivity. *Field Crop Res.* 66: 37-50.

Siddique, M. R. B., Hamid, A. and Islam, M. S. (2001). Drought stress effects on water relations of wheat. *Bot. Bull.Acad. Sinica,* 41 (1): 35-39.

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