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# Evaluation of Yield, Dry Matter Accumulation and Leaf Area Index in Wheat Genotypes as Affected by Terminal Drought Stress

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**Abstract**

Grain yield of wheat (*Triticum aestivum* L.) under Mediterranean conditions is frequently limited by both high temperature and drought during grain growth. In this region, most rain falls during autumn and winter and water deficit emerges in the spring, resulting in a moderate stress for rainfed wheat around anthesis, which increases in severity throughout grain filling. Hence, selection of genotypes with high grain yield is the principal aim of wheat production in this region. In order to evaluate yield and dry matter accumulation in wheat genotypes as affected by terminal drought stress, a factorial experiment based on a randomized complete block design was conducted in the Research Farm Islamic Azad University, Ardabil branch in 2009. Factors were: terminal drought stress by changing in planting date at three levels (12 October, 1 November and 21 November) with wheat (*Triticu aestivum* L.*)* genotypes at four levels ('Azar-2', 'Sardari', 'Frankia' and 'Trakia'). The results showed that various levels of terminal drought stress affected yield, dry matter accumulation and leaf area index in wheat genotypes. Mean comparisons showed that maximum grain yield (183.18 gr/m2) was obtained for the first planting date or the least duration of confronting with thermal drought stress in 'Azar-2' genotype and the minimum was obtained for the third planting date with 'Trakia' genotype due to the highest duration of confronting with thermal drought stress. Investigation of variance trends of dry matter accumulation indicated that in all of treatment compounds, it increased slowly until 190-200 days after sowing and then increased rapidly until 270-280 days after sowing. From 280 days after sowing to harvest time, it decreased due to increasing aging of leaves and decreasing of leaf area index. On the other hand, wheat genotypes had different responses to dry matter accumulation in confronting with thermal drought stress. Decrease in duration of terminal drought stress also significantly increased leaf area index and its maximum of it was observed by the plots that were applied on the first planting date with 'Azar-2' genotype. In all of the treatment compounds, LAI increased slowly until 190-200 days after sowing and then decreased slowly until 240-250 days after sowing. From 240-250 days after sowing until harvest time, it decreased rapidly due to hastened leaf senescence in confronting with terminal drought stress. Thus, it can be suggested that in order to increase grain yield, dry matter accumulation and leaf area index should be applied 'Azar-2' genotype with the first planting date(12 October ) should be applied in the conditions of the Ardabil Plain in Iran.

***Keywords:*** growth indices, terminal drought stress, wheat and yield

## Introduction

Drought stress is one of the most important environmental factors that it is effective on growth, development and production of plants. Drought, the result of low precipitation or high temperature is a non-uniform phenomenon, influencing the plants differently depending on the development stage at its occurrence (Vijendra Das, 2000; Lopez *et al.*, 2003). Wheat is one of the most important grain crops in the world. In regions with Mediterranean climate such as the west south of Iran, wheat is typically planted in late autumn and harvested in early summer. Thus, rainfall decreases and soil evaporation increases in spring when wheat (*Triticum aestivum* L.) enters the grain-filling period. On the other hand, during the grain filling period limited rainfall and high temperatures occur frequently and, consequently, water stress in this period is one of the major production constraints in these environments. Wheat is vulnerable to high temperature during most reproductive stages (Nicolas *et al.*, 1984; Wardlaw *et al.*,1989a; Tashiro and Wardlaw, 1990). Water deficit around anthesis may lead to a loss in yield by reducing spike and spikelet number and the fertility of surviving spikelets and from anthesis to maturity, especially if accompanied by high temperatures, hastens leaf senescence, reduces the duration and rate of grain filling and hence reduces mean kernel weight and dry matter accumulation (Giunta *et al*, 1993; Royo *et al*, 1999). Midmore *et al.* (1984), Shipler and Blum (1986), Zhong-hu and Rajaram (1994) in comparisons between favorable and high-temperature field environments found greater than fourfold differences in wheat yield. These differences were much greater than yield reductions by high temperature under controlled conditions. Similar results have been reported by Chowdhury and Wardlaw (1978) and Wardlaw *et al.* (1989a). In previous growth chamber studies, reduced yields were attributed mostly to lower kernel weight and only slightly to lower kernel number (Sofield *et al*., 1977; Chowdhury and Wardlaw, 1978; Wardlaw *et al*., 1989a, b; Tashiro and Wardlaw, 1990). Tashiro and Wardlaw (1990) and Guttieri *et al.* (2001) reported that dry matter accumulation decreased due to the decrease in kernel number, leaf number, kernel weight and acceleration of leaf senescence. Stone and Nicolas (1994) reported that dry matter accumulation, expansion and duration of green leaf area during kernel filling stage decrease when wheat encounters high temperatures. Warrington *et al.* (1977) and Tashiro and Wardlaw (1990) have been reported upon high temperatures during kernel filling (10 days after anthesis until ripeness) decreased wheat yield by reducing kernel weight. The objective of this study was the evaluation of yield and dry matter accumulation in wheat genotypes as affected by terminal drought stress in the condition of the Mediterranean climate such as the west south of Iran.

**Materials and methods**

A factorial experiment based on randomized complete block design with four replications was conducted in 2008 at the Research Farm of Islamic Azad University, Ardabili Branch (Alt. 1350 m). Climatically, the area is placed in the semi-arid temperate zone with cold winter and hot summer. Average rainfall is about 343 mm that most rainfall concentrated between winter and spring. The soil was loam silty with pH about 8.2. The Tab. 1 shows physical and chemical properties of farm soil used in the experiment. Mean temperatures and rainfall for the 2008 wheat growing season (October-August), are presented in Fig. 1.

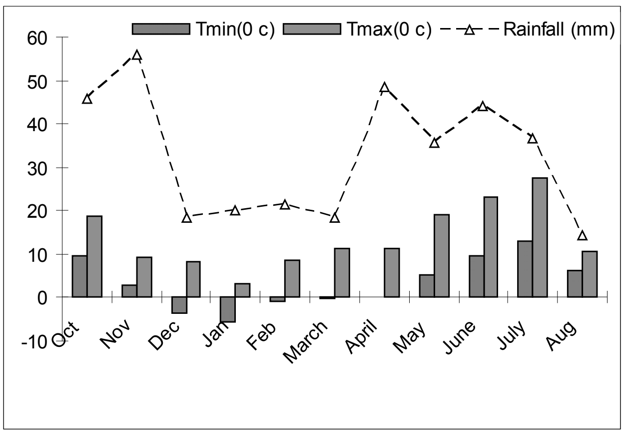


Fig. 1. Minimum and maximum temperatures and rainfall recorded during the period of wheat growth (October-August) in 2008

Before crop sowing the field was well prepared by tractor ploughing twice followed planking to make a fine seed bed. Treatments were terminal drought stress with a change of planting dates according to three levels containing (12 October, 1 November and 21 November) plus wheat genotypes on four levels ('Azar 2', 'Sardari', 'Frankia' and 'Trakia' ). The inter-row spacing was 20 cm. Seed lot viability was high (93%). Plot size was 7m×1.2 m with six rows per plot. Seeds were disinfected with Vitavax fungicide. Plots and blocks were separated by 0.5 m unplanted distances. Seeds were planted with 370 seeds $m^{-2}$. All other agronomic operations except those under study were kept normal and uniform for all treatments. For the estimation of dry matter accumulation from 0.2 $m^2$ in each plot samples were collected randomly in each treatment compound and average to record the change in dry weight in shoots (above ground). Sampling intervals were seven days at different stages of wheat growth (190, 200, 210, 220, 230, 240, 250, 260, 270, 280 and 290 days after sowing). For dry weight determination, samples were oven dried at 70±5°C to constant weight. The parameter of total dry matter (TDM) and leaf area index (LAI) were determined using equations (1) and (2) (Acuqaah, 2002 ; Gupta and Gupta, 2005).

$$TDM=e^{(a+bx+cx2+dx3)} \quad (1)$$

$$LAI= e^{(a+b\ +c^2)} \quad (2)$$

In these equations, t is the interval of sampling and a, b and c are coefficients of equation. 3 meters long harvest amples were taken from the three middle rows to measure grain yield. Analysis of variance was performed using SAS and Excel computer software packages.

**Results and discussion**

*Dry matter accumulation*

Study of the trend of variances for dry matter accumulation in wheat genotypes as affected by terminal drought stress in Fig. 2 showed that in all of genotypes, dry matter accumulation decreased during plant growth with an increasing duration of terminal drought stress (Fig. 2). Investigation of variances trends for dry matter accumulation indicated that in all treatment compounds, it slowly increased until 190-200 days after sowing and then increased rapidly until 270-280 days after sowing. From 280 days after sowing until harvest time, it decreased due to hastened leaf senescence and decrease of leaf area index. Similar results were also reported by Guttieri *et al.* (2001) and Stone and Nicolas (1995).

Tab. 1. Soil physico-chemical properties at a depth of 0-30 cm

| K available (mg/kg) | P available (mg/kg) | N total (%) | O.C (%) | Texture | Sand (%) | Loam (%) | Clay (%) | $CaCo_3$ (%) | SP (%) | pH | Depth of sampling (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 385 | 16 | 0.16 | 0.78 | Silty-loam | 24 | 70 | 5 | 18.3 | 46 | 8.2 | 0-30 |

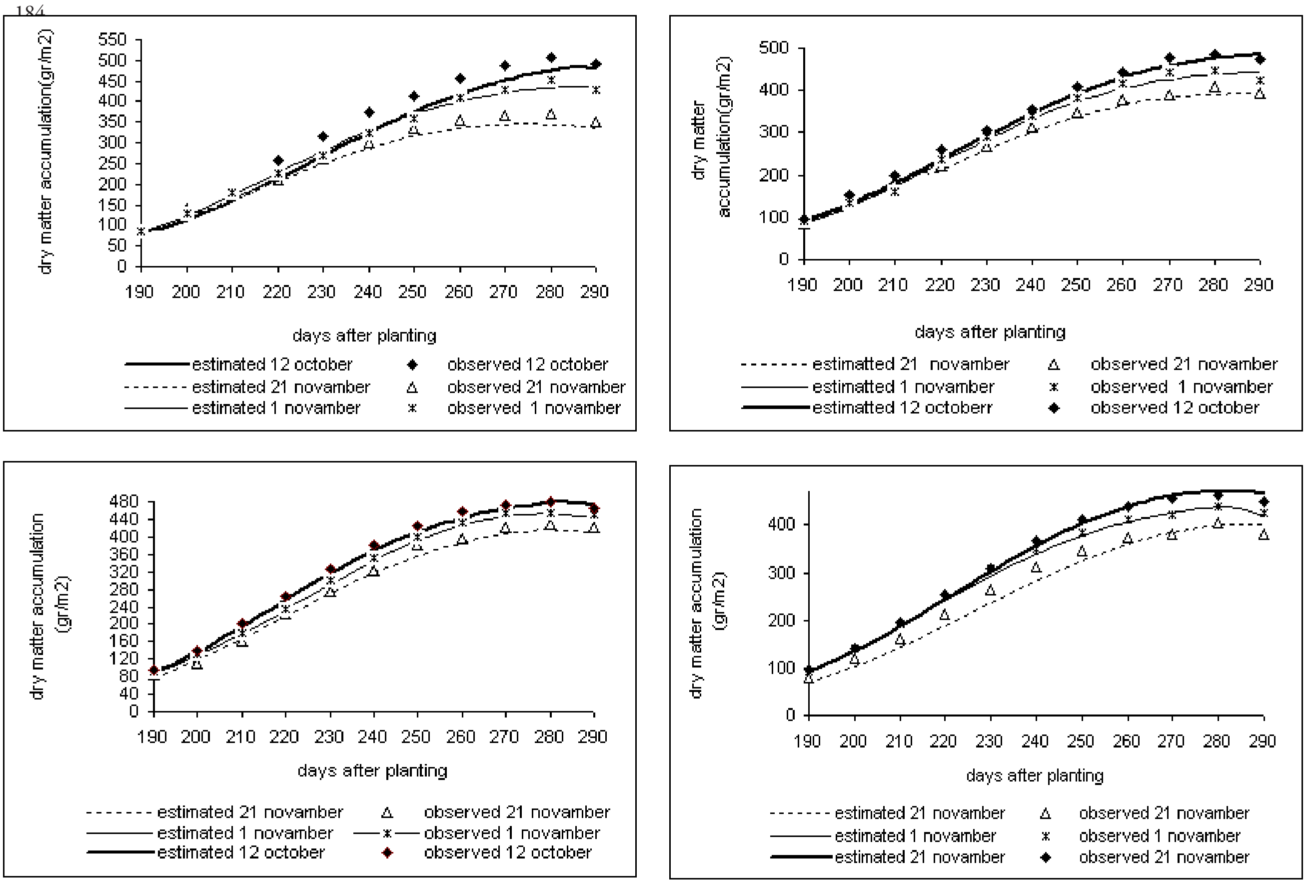


Fig. 2. Dry matter accumulation in 'Azar-2' (above left), 'Sardari' (above right), 'Frankia' (below left) and 'Trakia' (below right) genotypes planted at different dates (12 October, 1 November and 21 November)

The decrease in dry matter accumulation with the increase of duration of terminal drought stress indicates the unfavorable response of wheat genotypes to terminal drought stress. It is perhaps related to the decrease of the photosynthesis activity that has led to decrease in dry matter accumulation. Guttieri *et al.* (2001) reported that dry matter accumulation decreased due to a decrease in leaf number, leaf area index and acceleration in leaf senescence. The study on the dry matter accumulation trends of the 'Azar-2' genotype for various levels of terminal drought stress showed that dry matter accumulation increased slowly until 190-200 days after sowing and then increased rapidly until 270-280 days after sowing. From 280 days after sowing until harvest time, accumulated dry matter decreased due to increasing aging of leaves, decreasing of leaf area index (Fig. 3). On the other hand, accumulation of dry matter for area unit decreased with increasing duration of terminal drought stress, as the maximum and the minimum biomass for area unit obtained from 12 October and 21 November planting dates, respectively (Fig. 3). The study of the total dry accumulation in other genotypes ('Sardari', 'Frankia' and 'Trakia') indicated that it decreased in all of genotypes with the increase of duration of terminal drought stress and trends of variance were similar to dry matter accumulation in the 'Azar-2' genotype. Increasing leaf area index is one of the ways of increasing the capture of solar radiation within the canopy and production of dry matter. On the other hand, dry matter accumulation decreased with the decrease of leaf area index (Fig. 3).

In this study, the maximum value of total dry matter was obtained for the maximum value of leaf area index in the first planting date or the least duration of confronting with terminal drought stress. It is perhaps related to a relationship between leaf area index and accumulation of dry matter, especially when wheat encounters to drought stress or high temperatures. Our findings are in agreement with observations made by Warrington *et al.* (1977) and Tashiro and Wardlaw (1990). Midmore *et al*. (1984) and Zhong-hu and Rajaram (1994) in making comparisons between favorable and high-temperature field environments which reported that wheat yield and dry matter accumulation decreased with high temperature in during most reproductive stages when wheat (*Triticum aestivum* L.) enters the grain-filling period

*Leaf area index*

Study of variances trends for the leaf area index in Fig. 3 showed that in all of the genotypes, the leaf area index decreased during plant growth with the increasing duration of terminal drought stress and reached a maximum level 240-250 days after planting. From 250 days after sowing

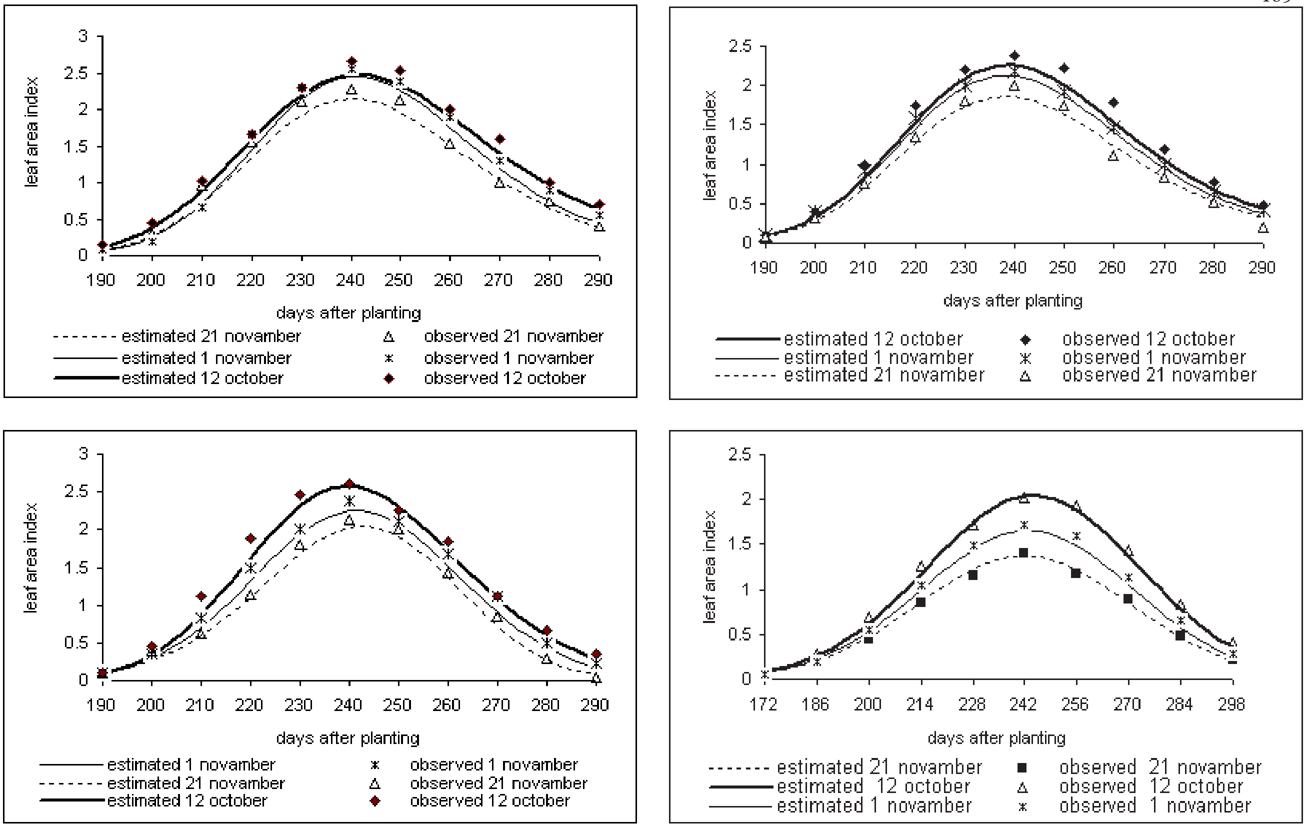


Fig. 3. Leaf area index in 'Azar-2' (above left), 'Sardari' (above right), 'Frankia' (below left) and 'Trakia' (below right) genotypes planted at different dates (12 October, 1 November and 21 November)

until harvest time, leaf area index decreased due to increasing aging of leaves, hastens leaf senescence, shading and competition between plants for light and other resources, especially, when wheat encounters drought stress or high temperatures. Increasing leaf area index is one of the ways of increasing the capture of solar radiation within the canopy and production of dry matter. Hence, dry matter produced decreases with a decrease of leaf area index. On the other hand, the trends of variances for leaf area index in

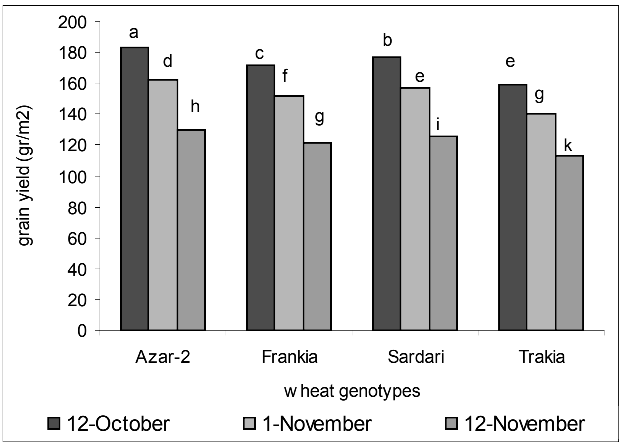


Fig. 4. Mean comparison of treatment compound of wheat genotypes in various levels of terminal drought stress on grain yield

treatment compounds of wheat genotypes × various levels of terminal drought stress were in accordance with the trend of variances for total dry matter. Similar results have also been reported by Tashiro and Wardlaw (1990).

*Grain yield*

Grain yield is the main target of crop production. Grain yield was significantly affected by wheat genotypes, terminal drought stress and interaction of wheat genotypes × terminal drought stress. Mean comparisons showed that maximum grain yield (183.18 $g/m^2$) was obtained at the first planting date or the least duration of confronting with thermal drought stress with 'Azar-2' genotypes and a minimum was obtained for the third of planting date with the 'Trakia' genotype or the highest duration of confronting with thermal drought stress (Fig. 4). These results are in agreement with total dry matter and leaf area index. This might be related to a correlation between grain yield with total dry matter and leaf area index. Weber *et al.* (1996) reported that both total dry matter and leaf area index were poor predictors of grain yield. Winter and Ohlrogge (1993) suggested that grain yield in each of treatment compounds is increased when leaf area index and total dry matter increased. In this study, grain yield increased when leaf area index and total dry matter increased.

## Conclusions

The grain yield of wheat (*Triticum aestivum* L.) under Mediterranean conditions such as the ones of the Ardabil province in the south west of Iran is frequently limited by both high temperature and drought during grain growth. In addition, selection of genotypes with high grain yield is the principal aim of wheat production in this region. Hence, in this experiment, terminal drought stress showed significant effects on grain yield, dry matter accumulation and leaf area index in wheat genotypes. The highest of these characteristics in wheat genotypes recorded for the first planting date with the 'Azar-2' genotype. In conclusion, it can be suggested that the 'Azar-2' genotype should be applied in the first planting date (12 October) in conditions of the Ardabil province in the south west of Iran.

## References

Acuqaah, G. (2002). Principle of Crop Production, Theory, Techniques and Technology. Prentice-Hall of India. Co. Pvt. Itd.

Chowdhury, S. I. and I. F. Wardlaw (1978). The effect of temperature on kernel development in cereals. Aust. J. Agric. Res. 29:205-223.

Giunta, F., R. Motzo and M. Deidda (1993). Effect of drought on yield and yield components of durum wheat and triticale in a Mediterranean environment. Field Crops Res. 33:399-409.

Gupta, N. K. and S. Gupta (2005). Pant Physiology. Oxford and IBH Publishing Co. Pvt.Itd.

Guttieri, M. J., J. C. Stark, K. Obrien and E. Souza (2001). Relative sensitivity of spring wheat grain yield and quality parameters to moisture deficit. Crop Sci. 41:327-335.

Lopez, C. G., G. M. Banowetz, C. J. Peterson and W. E. Kronstad (2003). Dehydrin expression and drought tolerance in seven wheat cultivars. Crop Sci. 43:577-582.

Midmore, D. J., P. M. Cartwright and R. A.Fischer (1984). Wheat in tropical environments II. Crop growth and grain yield. Field Crops Res. 8:207-227.

Nicolas, M. E., R. M. Gleadow and M. J. Dalling (1984). Effects of drought and high temperature on grain growth in wheat. Aust. J. Plant Physiol. 11:553-566.

Royo, C., J. Voltas and I. Romagosa (1999). Response of four spring wheat cultivars to drought stress. Crop Sci. 36:982-986.

SAS Institute (2000). SAS OnlineDoc. V. 8. SAS Inst., Cary, NC.

Shipler, L. and A. Blum (1986). Differential reaction of wheat cultivars to hot environments. Euphytica 35:483-492.

Sofield, I., L. T. Evans, M. G. Cook and I. F. Wardlaw (1977). Factors influencing the rate and duration of grain filling in wheat. Aust. J. Plant Physiol. 4:785-797.

Stone, P. J. and M. E. Nicolas (1995). A survey of the effects of high temperature during grain filling on yield and quality of 75 wheat cultivars. Aust.J.Agric. Res. 46:475-492.

Stone, P. J. and M. E. Nicolas (1994). Wheat cultivars vary widely in their responses of grain yield and quality to short periods of post-anthesis heat stress. Aust. J. Plant Physiol. 21:887-900.

Tashiro, T. and I. F. Wardlaw (1990). The effect of high temperature at different stages of ripening on grain set, grain weight and grain dimensions in the semi-dwarf wheat 'Banks'. Ann. Bot. (London) 65:51-61.

Vijendra Das, L. D. (2000). Problems facing plant breeding. CBS Publishers and Distributors. New Delhi. India.

Wardlaw, I. F., I. A. Dawson, P. Munibi and R. Fewster (1989a). The tolerance of wheat to high temperatures during reproductive growth. I. Survey procedures and general response patterns. Aust. J. Agric. Res. 40:1-13.

Wardlaw, I. F., I. A. Dawson, P. Munibi and R. Fewster (1989b). The tolerance of wheat to high temperatures during reproductive growth. I. Reproductive growth. Aust. J. Agric. Res. 40:15-24.

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

Weber, C. R., R. M. Shibles and D. E. Byth (1996). Effect of plant population and row spacing on soybean development and production. Agron. J. 58:99-102.

Winter, S. R. and A. J. Ohlrogge (1993). Leaf angle, leaf area and corn yield. Agron J. 65:395-397.

Zhong-hu, H. and S. Rajaram (1994). Differential responses of bread wheat characters to high temperature. Euphytica 72:197-203.