Vol. 44, N. 4 : pp. 325 - 330, December, 2001
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF BIOLOGY AND TECHNOLOGY

A N I N T E R N A T I O N A L J O U R N A L

Main Stem and Tiller Contribution to Wheat Cultivars Yield Under Different Irrigation Regimes

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ABSTRACT

The present study was carried out to determine the contribution of main stems and tillers to the total yield of two wheat cultivars (Triticum aestivum L.), Cocoraque and BH-1146, under two water treatments: a) normal field conditions, and; b) irrigation, in Londrina, PR, Brazil. The experiment was an eight replication randomized complete block design with treatments arranged in split-plots. Data on total grain yield, main stem grain yield, tillers grain yield, the ratio between tiller and total grain yield, yield components and other 17 traits were collected. The cultivar BH-1146 had a higher total grain yield in relation to Cocoraque under normal field conditions; i, e., under water stress. Main stem grain yield responded positively and significantly to irrigation which was the main cause of increased yield in both cultivars. The tiller grain yield contributed little to the total yield.

Key words: Harvest index, growth period, hectolitric weight, poaceae, water stress

INTRODUCTION

Rain is scarce in various regions during the wheat cultivation period. Water stress reduces wheat grain yield (Davidson and Chevalier, 1990; Jat et al., 1990; Sairam et al., 1990; Kobata et al., 1992; Thompson and Chase, 1992; Ravichandran and Mungse, 1997; Villareal et al., 1998; Guerra and Antoninini, 1996). Tubelis and Souza (1983) studied the effect of irrigation on wheat yield. They found that irrigation could increase yield up to 4.7 times in years with low rainfall during the plant growth period.

Reduction in grain yield also depends on the genotype cultivated and the physiological stage of the plants under stress (Hobbs, 1953 ; Robins and Domingo, 1962; Singh et al., 1979; Sairam et al., 1990; Blum et al., 1990; Thompson e Chase, 1992; Moustafa, et al., 1996; Ravichandran e Mungse, 1997; Villareal et al., 1998; Guerra e Antonini, 1996). Souza and Soares Sobrinho (1983) found that the BH-1146 cultivar had more stable yield under the most adverse environmental conditions due to its tolerance to toxic acid soils, drought, temperature variations and different sunlight conditions.

When the initial plant population density is low in fields cultivated with tillering wheat cultivars, yield is not usually diminished. Under this condition, plants produce more tillers than in high plant density populations and the crop cycle finishes with very similar numbers of ears per

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square meter, and the grain yield is not significantly affected. When cultivars do not have good tillering capacity and the initial plant population is very low, the crop cannot completely compensate the number of ears per square meter and yield is reduced (Wall, 1982).

This study was carried out to assess the influence of water on grain yield in the main stems and tillers of the Cocoraque and BH-1146 wheat cultivars.

MATERIAL AND METHODS

The study was carried out in Londrina, Paraná, Brazil, latitude 23º22'S, longitude 51º10'W at an altitude of 585 meters, with Cfa climate according to Köppen. The topography is gently rolling and the soil is structured eutrophic ´terra roxa´ (Hapludult).

A randomized complete block design with eight replications and treatments arranged in split plots was used. Each block consisted of two 1.80 m x 3.00 m plots which corresponded to the irrigated (up to field capacity) and non-irrigated treatments. Each plot was divided into two sub-plots which corresponded to the Cocoraque and BH-1146 cultivars used. 'Cocoraque' is a representative of the Mexican wheat gene pool having high yield potential, good quality, short stature and high tillering capacity. 'BH-1146' is a traditional Brazilian wheat with medium-low yield potential, poor quality, tall stature and low tillering capacity, but having aluminum tolerance which is an important adaptative trait. Today, the majority of the wheat cultivars under cultivation in Brazil are products from the combination of Brazilian by Mexican germplasm.

The distance between blocks and between plots was 1.5m to prevent errors due to soil moisture. The lines were spaced at 0.18m and the sowing density was 400 seeds/m2. The experiment was sowed on April 29 and harvested in the beginning of September 1986.

Irrigated plots were irrigated bi-weekly as necessary to bring total rainfall and irrigation amounts above 25 $mm.week^{-1}$. The Agronomic Institute of Paraná, IAPAR, provided the mean temperature for the daily evapotranspiration calculation. Table 1 shows the rainfall and mean temperature for each 10-day period from May to August 1986. Rainfall was abundant in May at the initial stages of plant development and from August 10 onwards at the crop maturing stage. There were only 22 mm of rain from the first ten days in June to the first ten days in August (seven mm in the first ten days of June and 15mm in the last ten days of July).

Table 1 - Rainfall and mean temperature per 10-day period, from May to August 1986. UEL, Londrina, Pr.

Month	Ten-day	Rainfall (mm)	Mean Temperature (ºC)
May	1st	17	19,4
May	2nd	77	20,2
May	3rd	40	18,0
June	1st	00	15,5
June	2nd	00	18,9
June	3rd	00	17,4
July	1st	07	15,5
July	2nd	00	17,5
July	3rd	15	15,7
August	1st	00	20,8
August	2nd	115	15,8
August	3rd	39	18,6

Plots were irrigated manually with watering cans, by a single person, to prevent errors in water application. All plots were irrigated to field capacity shortly after sowing. Lime and fertilizer were applied according to the technical recommendations based on soil analysis. Samples were taken at harvest. All plants in a linear meter of the sub-plots were randomly harvested. Data was transformed to square root when necessary for the analysis. Means were compared by the Duncan Test at the 5% level of significance. Data were assessed as follows:

A. Yield: After weighing and determining of the grain moisture, the data was made uniform to 0% moisture, and the following traits were scored: 1 – total grain yield: the tiller yield was added to the main stem yield and transformed to kg/ha; 2 – main stem grain yield: weight of sample main stem grains in grams; 3 – tiller grain yield: weight of the sample tiller grains in grams; 4 – percentage ratio between tiller and total grain yield: quotient between tiller grain yield / total grain yield, multiplied by 100;

B. Yield components: 1 – number of plants / linear meter: sample number of main stem; 2 – number of fertile tillers / linear meter: sample number of fertile tillers (at least one grain on the ear); 3 – number of fertile tillers / plant: sample number of fertile tillers divided by the sample plant number; 4 – number of fertile spikelets/ear on the main stem: ten ears were randomly taken and the number of fertile spikelets/ear were counted on the main stem and then the mean was calculated; 5 – number of fertile spikelets/ear on the tillers: same as in item 4 on the tillers; 6 – number of main stem grains/ear: the grains of the same sample as item 4 were counted and the mean calculated; 7 – number of grains/ear on the tillers: the grains of the same sample as in item 5 were counted and then the mean was calculated; 8 – grain weight/main stem ear: main stem yield by the sample number of main stems, in grams; 9 – grain weight/tillers: same as in item 8 for tillers;

C. Harvest index: 1 – main stem harvest index: grain weight divided by the sample main stem canopy weight; 2 – tiller harvest index: same as in item 1, for the tillers;

D. Individual grain weight: 1 – main stem individual grain weight: sample hundred grains mean weight in grams; 2 – tiller individual grain weight: same as in item 1 for the tillers;

E. Hectoliter weight: weight of a hundred liters of wheat assessed by a specialized device, using the total yield of the sub-plot;

F. Plant height: 1 – main stem height: mean height of the sample main stems, in centimeters; 2 – tiller height: same as in item 1, for the tillers;

G. Number of days to maturity: days from sowing to harvest maturity (dry straw), according to the Feeks and Large scale (Large, 1954).

RESULTS AND DISCUSSION

Table 2 shows the results for all the assessed traits. Irrigation significantly increased the total and the main stem grain yield in the two tested cultivars (5% level of probability by the Duncan test). The tiller yield and the tiller/total yield ratio only increased in the Cocoraque cultivar. The BH-1146 cultivar showed a better total and main stem grain yield performance in the non-irrigated treatment than the Cocoraque. Souza and Soares Sobrinho (1983) also reported that the BH-1146 cultivar adapted better to water stress. Moustafa et al. (1996) and Villareal et al. (1998) showed that certain cultivars react better under water stress.

The Cocoraque cultivar highest tiller/total yield ratio was 11.6%. These results indicate that the tillers can only partially compensate for a low initial wheat population, even when the cultivar has good tillering capacity like the Cocoraque. Wall (1982) did not mention limits for crop recovering capacity due to a initial low population. However, Metho et al. (1998) show that the yield capacity of the tillers compared to main stems varied widely among cultivars.

Table 2 - Means of 21 agronomic traits assessed in two wheat cultivars submitted to two water treatments. UEL, Londrina, PR.

Assessed trait	Cocoraque			BH-1146			Média		CV (%)	
	Irrigated	Non- irrigated	Mean	Irrigated	Non-irrigated	Média	Irrigated	Non-irrigated	Plot	Sub-plot
Total grain yield	3.087.4aA	1.817.2bB	2.452.3A	3.259.7aA	2.371.9bA	2.815.8A	3.173.54a	2.094.5b	9.31	11.4
Main stem grain yield	48.41 aA	30.65 bB	39.53 B	56.55 aA	41.975 bA	49.263 A	52.48 a	36.31 b	7.17	10.8
Tiller grain yield	7.16 aA	2.08 bA	4.62 A	2.125 aB	0.72 aA	1.423 B	4.64 a	1.40 b	39.0	42.8
(Tiller grain yield / Total grain yield) x 100	11.58 aA	4.71 bA	8.145 A	5.58 aB	1.61 aA	2.595 B	7.58 a	3.16 b	47.2	48.1
No. of plants/linear m	73.88 aA	78.50 aA	76.19 A	73.00 aA	67.75 aA	70.375 A	73.44 a	73.125 a	3.89	8.42
No. of fertile tiller/m	13.88 aA	7.00 bA	10.44 A	10.50 aA	6.38 aA	8.44 A	12.19 a	6.69 a	28.0	30.1
No. of fertile tiller/plant	0.190 aA	0.086 bA	0.138 A	0.145 aA	0.093 aA	0.119 A	0.168 a	0.0895 a	28.7	28.1
No. fertile spikelets/ ear on main stems	10.24 aB	8.40 bA	9.32 B	12.33 aA	12.49 aA	12.41 A	11.285 a	10.445 b	2.03	2.80
No. fertile spikelets/ ear on tillers	8.16 aA	4.53 bA	6.345 A	7.35 aA	4.45 bA	5.90 A	7.755 a	4.90 b	14.7	18.1
No. of grains/ear on main stems	16.36 aA	10.41 bB	13.385 B	19.31 aA	17.45 aA	18.38 A	17.835 a	13.93 b	8.93	11.6
No. of grains/ear on tillers	14.58 aA	7.23 bA	10.905 A	6.93 aB	5.90 aA	6.415 B	10.755 a	6.565 b	16.7	28.4
Main stem grain weight/ear (g)	0.66 aA	0.39 bB	0.525 B	0.79 aA	0.65 aA	0.72 A	0.725 a	0.52 b	7.83	10.8
Tillers grain weight/ear(g)	0.48 aA	0.19 bA	0.335 A	0.20 aB	0.13 aA	0.165 B	0.34 a	0.16 b	20.2	34.9
Main stem harvest index	0.420 aA	0.304 bB	0.362 B	0.388 aA	0.400 aA	0.394 A	0.404 a	0.352 b	3.01	7.60
Tillers harvest index	0.418 aA	0.244 bA	0.331 A	0.215 aB	0.235 aA	0.225 B	0.317 a	0.240 b	13.3	23.4
Main stem individual grain weight (g)	0.0404 aA	0.0375 bA	0.0390 A	0.0404 aA	0.0371 bA	0.0388 A	0.0404 a	0.0373 b	0.73	1.08
Tillers individual grain weight (g)	0.0332 aA	0.0248 bA	0.0290 A	0.0292 aA	0.0179 bA	0.0236 B	0.0312 a	0.0214 b	8.09	13.9
Hectolitric weight (kg/100 l)	76.89 aB	76.25 aA	76.57 B	78.05 aA	76.65 bA	77.35 A	77.47 a	76.45 b	0.54	0.57
Main stem height (cm)	65.88 aB	58.41 bB	62.15 B	93.57 aA	86.62 bA	90.095 A	79.725 a	72.515 b	1.80	3.08
Tillers height (cm)	65.01 aA	53.91 bA	59.46 A	76.44 aA	54.43 bA	65.435 A	70.725 a	54.17 b	3.52	8.63
No. of days to maturity	126.25 aA	122.50 bA	124.38 A	117.63 aB	113.13 bB	115.38 B	121.94 a	117.815 b	0.20	0.55

[1] Means followed by different tiny letters, in the line (compare water treatments), and different capital letters, also in the line (compare cultivars from each water treatment), differ by the Duncan test (P<0.05)

There was no statistically significant difference in plant density (number of plants per linear meter of row) between water treatments or cultivars. Irrigation significantly increased the number of fertile tillers per linear meter and the number of fertile tillers per plant only for the Cocoraque cultivar. Irrigation, however, increased the number of panicles per square meter and the number of grains per panicle (Zhang et al., 1998).

Irrigation increased the number of fertile spikelets/ear on the main stem only in the Cocoraque cultivar, while the number of fertile spikelets/ear on the tillers increased in both cultivars. The number of fertile spikelets/ear on the BH-1146 cultivar main stems was significantly greater than on the Cocoraque in the irrigated treatment. On the other hand, there was no significant difference for the number of fertile spikelets/ear on the tillers. The number of grains/ear on the main stems and tillers increased significantly at the 5% level of probability only in the Cocoraque cultivar. The main stem number of grains/ear was significantly greater in the BH-1146 cultivar comparatively to the Cocoraque in the non-irrigated treatment. The tiller number of grains/ear was significantly greater in the Cocoraque cultivar only in the irrigated treatment.

It was noticed that irrigation resulted in increase of the weight of grain/ear of the main stem and tillers significantly only in the Cocoraque cultivar. The main stem grain weight/ear was significantly greater in the BH-1146 cultivar in the non-irrigated treatment, while the tiller grain weight/ear in the Cocoraque cultivar was only significantly superior in the irrigated treatment. Irrigation also increased the harvest index of the main stems and tillers significantly only in the Cocoraque cultivar. The harvest index of the tillers was significantly greater in the BH-1146 cultivar in the non-irrigated treatment, while the tiller harvest index of the Cocoraque cultivar was significantly greater only in the irrigated treatment. Variation in water regimes causes different responses in the genotype harvest index (Villareal et al., 1998).

The individual grain weight of the main stems also increased significantly and tillers in the two cultivars, but there were no differences within any water treatment. Supplementary irrigation during the plant development only increased significantly the hectoliter weight in the cultivar BH-1146. The BH-1146 cultivar was superior to the 'Cocoraque' only in the irrigated treatment. The hectoliter weight was generally low because of rain at maturity (see Table 1). The value established for wheat commercialization is 78 kg/hectoliter and the mills pay 1% more for wheat for each percentage point above 78 kg (Guerra and Antonini, 1996).

The main stem and tiller heights of both cultivars decreased under water stress. Differences between the two water treatments could be explained by the fact that the lower cell turgidity caused by water stress decreases growth by lengthening (Hsiao, 1973; Tyree and Jarvis, 1982; Kramer and Boyer, 1995). The BH-1146 cultivar was significantly superior to the Cocoraque both in the irrigated and in the non-irrigated treatment for the main stem height. There were no significant differences among the tested cultivars for tiller height, either in the irrigated or non-irrigated treatment. The higher BH-1146 cultivar plant height resulted in lodging problems under irrigation.

The plant cycle was significantly longer in the irrigated treatments for both cultivars. The Cocoraque cultivar was tardier than the BH-1146, both under irrigation and without irrigation. Grains from wheat plants grown under good water supply (irrigation) conditions reach physiological maturity up to 20 days later than those from plants submitted to water stress (Villareal et al, 1998).

In the two cultivars used, irrigation increased the total and the main stem grain yield, the number of fertile spikelets/ear on the tillers, the main stem and tiller grain weight, the main stem and tiller height and the number of days to maturity. Irrigation also increased the tiller grain yield, the percentage ratio between tiller grain yield and total grain yield, the number of fertile tillers per linear meter, the number of fertile tillers per plant, the number of fertile spikelets/ear in the mean stems, the number of grains per ear in the main stems and tillers, the main stem and tiller grain weight per ear, and the main stem and tiller harvest index of the Cocoraque cultivar, which has the greatest tillering capacity.

The Cocoraque cultivar was superior to the ‘BH-1146’ under irrigation for tiller grain yield, percentage ratio between tiller and total grain yield, tiller number of grains per ear, tiller grain weight per ear, tiller harvest index and number of days to maturity. Under irrigation, the BH-1146 cultivar was superior to the Cocoraque for main stem number of fertile spikelets/ear, hectoliter weight and main stem height.

In the non-irrigated treatment, the BH-1146 cultivar was superior to the Cocoraque for total grain yield, main stem grain yield, number of grains per main stem ear, grain weight per main stem ear, main stem harvest index and main stem height. The Cocoraque cultivar was tardier than the BH-1146 cultivar in the non-irrigated treatment. The traits assessed in the tillers had a greater variation coefficient than those in the main stems, possibly because of the lower values observed in the tillers.

CONCLUSIONS

1. Irrigation increased the total grain yield of the wheat crop in environments under water stress.

2. Less water availability decreased the main stem and tiller heights and the number of days to maturity in wheat.

3. The BH-1146 cultivar had more stable total grain yield comparatively to the Cocoraque cultivar.

4. The tiller grain yield had little influence in the grain yield, representing at most 11.6% of the total yield.

5. The increase in the tiller grain yield due to the increase in water availability was cultivar dependent. The Cocoraque cultivar was more responsive than ‘BH-1146’.

ACKNOWLEDGEMENTS

The authors thank CNPq and CAPES for grants and financial support. We also thank Dr. Carlos Roberto Riede (Instituto Agronômico do Paraná, Melhoramento e Genética, Londrina, PR, Brazil) for reviewing this manuscript.

RESUMO

No presente trabalho, determinou-se a contribuição dos afilhos e perfilhos na produtividade total de dois cultivares de trigo (*Triticum aestivum L.)*, Cocoraque e BH-1146, submetidos a dois regimes hídricos, um exposto as condições normais de campo e outro sobre regime de irrigação, em Londrina, PR, Brasil. Utilizou-se o delineamento blocos completamente casualizados, com parcelas subdivididas, com oito repetições. As características avaliadas foram

produtividade total de grãos, produtividade de grãos dos afilhos e perfilhos, relação da produtividade de grãos dos perfilhos pela produtividade total de grãos, componentes de produtividade e outros dezessete caracteres. Os resultados mostraram que o cultivar BH-1146 apresentou maior produtividade total de grãos, em condições de déficit hídrico, em relação ao cultivar Cocoraque. A produtividade dos afilhos respondeu positiva e significativamente à irrigação, sendo esta a principal causa do aumento de produtividade dos dois cultivares testados. A produtividade de grãos dos perfilhos pouco representou na produtividade total de grãos.

REFERENCES

Blum, A.; Ramaiah, S.; Kanemasu, E. T. and Palsen, G. M. (1990), Wheat recovery from drought stress at the tillering stage of development. *Field Crops Research*, **24**, 67-85.

Davidson, D. J. and Chevalier, P. M. (1990), Preanthesis tiller mortality in spring wheat. *Crop Science*, **30**, 832-836.

Guerra, A. F. and Antonini, J. C. A. (1996), Época de suspender as irrigações da cultura do trigo. *Pesquisa Agropecuária Brasileira*, **31**, 823-828.

Hsiao, T. C. (1973), Plant responses to water stress. *Annual Review of Plant Physiology*, **24**, 519-570.

Hobbs, J. A. (1953), The effect of spring nitrogen fertilization on plant characteristic of winter wheat. *Soil Science Society os American Proceedings*, **17**, 39-42.

Jat, K. R; Muralia, R. N. and Kumar, A. (1990), Physiology of drought tolerance in wheat (Triticum aestivum L.). I. Growth and yield. *Comparative Physiology and Ecology*, **15,** 147-158.

Kramer, P. J. and Boyer, J. S. (1995), *Water relations of plants and soils.* San Diego: Academic Press. 495p.

Kobata, T.; Palta, J. A. and Turner, N. C. (1992), Rate os development of postanthesis water deficits and grain filling of spring wheat. *Crop Science*, **32**, 128-129.

Large, E. C. (1954), Growth stages in cereals; illustration of the feeks scale. *Plant Pathology*, .**3**, 128-129.

Metho, L. A.; Hammes, P. S. and Beyers, E. A. (1998), The effect of soil fertility on the contribution of main stem, tillers and kernel position to grain yield and grain protein content of wheat. *South African Journal of Plant and soil*, **15**, 53-60.

Moustafa, M. A.; Boersma, L and Kronstad, W. E. (1996), Response of four spring wheat cultivars to drought stress. *Crop Science*, **36,** .982-986.

Ravichandran, V. and Mungse, H. B. (1997), Response of wheat to moisture stress at critical growth stages. *Annals of Plant Physiology*, **11**, 208-211.

Robins, J. S. and Domingo, C. E. (1962), Moisture and nitrogen effects on irrigated spring wheat. *Agronomy Journal*, **54,** 135-138.

Sairam. R. K.; Deshmukh, P. S.; Shukla, D. S. and Ram, S. (1990), Metabolic activity and grain yield under moisture stress in wheat genotypes. *Indian Journal of Plant Physiology*, **33,** 226-231.

Singh, N. T.; Vig, A. A.; Singh, R. and Chaudhary, M. R. (1979), Influence of different levels of irrigation and nitrogen on yield and nutrient uptake by wheat. *Agronomy Journal*, **71,** 401-404.

Souza, M. A. and Soares Sobrinho, S. J. (1983), Cultivares do trigo para Minas Gerais. *Informe Agropecuário*, **97**(9), 20-26.

Thompson, J. A. and Chase, D. L. (1992), Effect of limited irrigation on growth and yield of a semi-dwarf wheat in southern New South Wales. *Australian Journal of Experimental Agriculture*, **32**, 725-730.

Tubelis, A. and Souza, F. G. A. (1983), Efeito da irrigação na produtividade da cultura do trigo. *Pesquisa agropecuária brasileira*, **18,** 1359-1367.

Tyree, M. T. and Jarvis, P. G. (1982), Water in tissues and cells. In: Lange, O. L.; Nobel, P. S.; Osmond, C. B. and Ziegler, H., eds. *Physiological plant ecology II; encyclopedia of plant physiology new sens*, Berlin, Springer-Verlag, **12B**, 36-71.

Villareal, R. L; Banvelos, O; Mujeeb-Kazi, A. and Rajaram, S. (1998), Agronomic performance of chromosomes 1B and T1BL.1RS near-isolines in the spring bread wheat Seri M82. *Euphytica*, **103**, 195-202.

Zhang, J.; Sui, X.; Li, B.; Su, B.; Li, J. and Zhou, D. (1998), An improved water-use efficiency for winter wheat grown under reduced irrigation. *Field Crops Research*, **59,** 91-98.

Wall, P. C. (1982), Algunos Efectos del clima y el ambiente sobre el crescimiento, desarrolo y rendimiento de trigo. In: Diaz, R.; Mc Mahon, M. *Seminário sobre: Tecnologia de trigo*. La Estanzuela: CIMMYT, 12-16.

Received: January 14, 2000;
Revised: February 23, 2000;
Accepted: May 18, 2000.