Trophic control of tillering rate of three rice cultivars (*Oryza sativa* L. and *O. glaberrima* Steud.) under different drought levels

F. Tivet[1], B. da Silveira Pinheiro[2], M. de Raïssac[1], M. Dingkuhn[1]

1 CIRAD, TA70/01, Avenue Agropolis, 34398 Montpellier Cedex 5, France
2 EMBRAPA, Centro Nacional de Pesquisa de Arroz e Feijão, C.P. 179, 74001-970 Goiânia GO, Brasil
Corresponding author. E-mail:dingkuhn@cirad.fr

Tillering capacity of rice depends on the genotype, on resources available for growth and the level of physiological stresses. The aim of this work is to examine tillering dynamics of three genetically contrasting rice cultivars: IAC47 (upland-adapted, O. sativa, japonica, low-tillering), Javaé (lowland-adapted, O. sativa, indica, high-tillering) and CG14 (broadly adapted, O. glaberrima)

Material and methods

The experiments involved three genetically contrasting rice cultivars:
- IAC47, a traditional, O. sativa, japonica, upland type;
- Javaé, a semidwarf, O. sativa, indica, type grown in lowland and irrigated ecosystems;
- CG14, a traditional, upland and lowland adapted, photoperiod-sensitive, O. glaberrima type.

❑ **Greenhouse experiment.** Conducted in 1997 on the EMBRAPA Research Experiment Farm (16.28° S, 49.17° W, and 823 m als), near Goiânia. Randomised complete block, using 3 cultivars, 3 water regimes with 18 replicates. The soil was a latosol. One day before sowing, a pre-mixed fertiliser and micronutrients was applied to each pot. At about panicle initiation, 85 mg N.kg^{-1} dry soil as ammonium sulphate was applied. Plants were thinned to 6 per pot at emergence, 2 per pot at the appearance of the 3rd leaf and 1 per pot at the appearance of the 7th leaf on the main stem.

Three water regimes were imposed: continuous watering to field capacity or reduced watering (moderate stress = - 0.025 MPa and severe stress = - 0.060 MPa matrix potential) from the appearance of the 3rd leaf to the appearance of the flag leaf on the main stem. The soil was kept at a constant bulk water content, weighing and watering of pots every day.

Photo 1. IAC47, low-tillering type.

Photo 2. CG14, high-tillering type.

❑ **Field experiments.** In 1997 at the EMBRAPA research experiment farm. Sowing during the cold dry season (10 April) and the hot dry season (22 July) in a randomised block design with 4 replicates. Plots surface area was 22 m^2. Plant density: 120 plants.m^{-2} (cold dry season) and 85 plants.m^{-2} (hot dry season). The soil was a latosol. Fertiliser application according to local recommendations and plots were kept weed free. Sprinkler irrigation was used to keep the soil at field capacity.

❑ **Sampling.** For the greenhouse experiment, at each sampling, 4 to 6 plants were separated into roots and shoots, the shoot into individual tillers, and tillers into separate visible leaves (green and dead part of leaf blades), sheaths and internodes. Destructive measurements were carried out 4-5 times on field experiments on 4 sub-plots of 0.5 m^2 per cultivar.

❑ **Number of tillers and genealogy.** Emerged tillers were counted on all plants and their genealogy was determined.

Phenological analysis

Significant differences in tiller number between cultivars under well-watered conditions were observed from 40 DAE onwards, corresponding approximately to the appearance of the nineth leaf. Javaé and CG14 significantly produced more tillers than IAC47 in all treatments. Drought effects on tillering were small during the period of exponential growth (until ca. 40 DAE) but became very pronounced thereafter. The relative reduction in tiller number for the moderate (severe) drought treatment at the stage of flag leaf appearance was 23% (43%) for CG14, 5% (48%) for Javaé and 35% (35%) for IAC47.

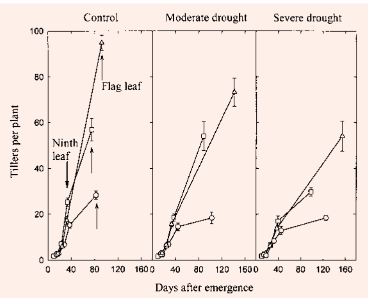

Fig. 1. Changes in number of emerged tillers for isolated plants, three drought treatments and three cultivars (○ IAC47; □ Javaé; △ CG14). Error bars indicate the standard errors (SE) for means of four to six replications.

Patterns of individual leaf blade area for the primary tillers showed a strong relationship with that of the main stem for all cultivars and drought treatment. Area of subsequently blades increased during vegetative development and then decreased. Drought had no effect on these relationships between culms. The first leaves of the tillers were more similar in size to those of a seedling.

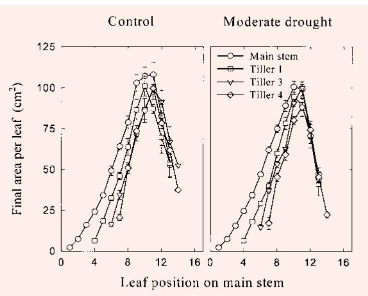

Fig. 2. Area of fully expanded leaves for the main stem (a) and the first primary tillers (b) as a function of leaf position for control and moderate drought treatments on IAC47. Error bars indicate standard errors (SE) for means of three to twenty-six replications depending of developmental stage.

Growth analysis

In order to compare effects of growth stage (a), drought treatment (b) and cultivar (c), regressions were performed on data bulked according to these factors. A stable and uniform, linear relationship was found between RTR and RGR for two sources of variation (drought and cultivar). The intercepts on X and the slopes of the first three stages differed from the fourth stage at the 0.001 probability level.

The intercept on X for the overall regression line (RTR = - 0.014 + 0.619*RGR, R^2 = 0.84) was 0.023 g.g^{-1}.d^{-1}, indicating that no positive tillering occurred at RGR below that value. At any developmental stage, RGR of Javaé and CG14 were at least 10% higher than that of IAC47.

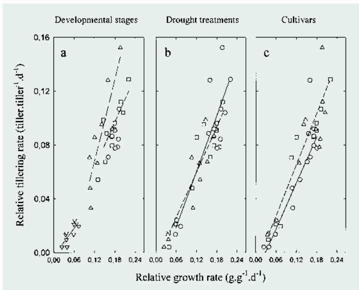

Fig. 3. Relationships between relative tillering rate and relative growth rate based on developmental stage (a: ○ stage 1, dotted; □ stage 2, short dash; △ stage 3, long dash; ▽ stage 4, solid line), drought treatments (b: ○ control, solid line; □ moderate, short dash; △ severe, dotted) and cultivars (c: ○ IAC47, solid line; □ Javaé, short dash; △ CG14, dotted). Lines indicate linear regressions.

Simulation of tiller production, using a cultivar specific relationship RTR vs RGR, gave a reasonably good fit with observations for the vegetative growth phase (from the seedling emergence to 40 days after emergence) in two-independant, well-watered, field trials. Consequently, this relationship RTR vs RGR is valid for both isolated plants and field crops.

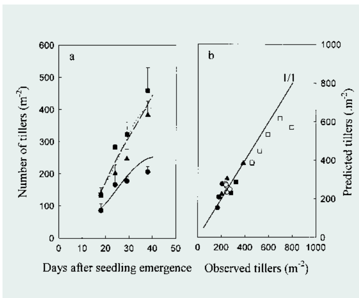

Fig. 4. Two experiments (white and black symbols) conducted under field conditions in Goiânia (Brazil). ○ IAC47; □ Javaé; △ CG14 (means of four replications).
a) Number of tillers per plant. Lines indicate simulations using a relative tillering (RTR) vs relative growth rate (RGR) relationship taken from greenhouse-based observations (solid line, IAC47; dotted line, CG14; short dash, Javaé).
b) Predicted versus observed tiller numbers.

Conclusion

❑ Leaf appearance is synchronized across tillers.
❑ New tillers repeatedly 'catch-up' with the mainstem in term of leaf size but not number.
❑ Tillers number depends on biomass growth and not on bud number.
❑ Varietal tillering capacity is due to growth rate.

Centre de coopération internationale en recherche agronomique pour le développement

References
Bos, H.J., Neuteboom, J.H., 1998. Annals of Botany 81, 131-139.
Dingkuhn, M., Schnier, M., Dörffling, K., Javellana, C., 1991. Field Crops Research 26, 327-345.
Dingkuhn, M., Jones, M.P., Johnson, D.E., Sow, A., 1998. Field Crops Research 57, 67-69.
Dingkuhn, M., Asch, F., 1999. Euphytica 110, 109-126.
Hanada, K., 1993. 2. In: Matsuo, T., Hoshikawa, K. (Eds). Science of the Rice Plants. Vol. I. Morphology. Food and Agricultural Policy Research Center, Tokyo, pp. 222-258.
Murphy, J.S., Briske, D.D., 1992. Journal Range Management 45, 419-429.
Schnier, M., Dingkuhn, M., De Datta, S.K., Mengel, K., Wijanco, E., Javellana, C., 1990. Agronomy Journal 82, 451-459.

Document obtenu sur le site Cirad du réseau http://agroecologie.cirad.fr

Design and production: Cirad-dist, fax: 33(4) 67 61 55 13 - July 2000