GROWTH, DEVELOPMENT AND YIELD COMPONENTS OF RICE PLANTS GROWN IN RESTRICTED SOIL VOLUME

Nereu Augusto Streck, Isabel Lago, Felipe Brendler Oliveira, Ana Paula Schwantes, Luana Fernandes Gabriel, Luis Antonio de Avila. Departamento de Fitotecnia, Centro de Ciências Rurais, Universidade Federal de Santa Maria, 97105-900, Santa Maria, RS - e-mail: nstreck1@smail.ufsm.br.

Crop growth and development are affected by availability of water and nutrients, which in turn is dependent primarily on the volume of soil occupied by roots. PETERSON et al. (1984) showed that wheat plants grown in small pots (mean soil volume of 55 ml/plant) had their growth reduced (less tillers/plant, lower area of individual leaves, lower main stem height, and lower above-ground and below-ground dry weight) than plants grown in relatively larger pots (mean soil volume of 1133 ml/plant). However, the results by PETERSON et al. (1984) also revealed that wheat plants development, measured by the leaf appearance rate and the Haun Stage (HAUN, 1973) at tiller appearance, was not different for plants grown in the smallest and in the largest pots, showing that plant growth and plant development have to be treated as independent variables and they are not affected by the same environmental factors. A good rational for a scientific effort is to extend studies on the effect of restricting rooting on rice plant growth and development. The objective of this study was to asses the effect of restricting soil volume on the growth, development, and yield components of rice plants.

An experiment was conducted in the research area of the Crop Science Department, of the Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brazil, during the 2006/07 growing season. Rice plants were grown in pots in a paddy rice field. Pots were 30 cm in diameter and 26 cm deep, corresponding to a 12-liter volume. Pot spacing was 1.5m x 0.8m. The paddy rice field was an area grown for several years with flooded rice. Two widely grown rice cultivars (IRGA 421 and EPAGRI 109) in Southern Brazil were used. The cultivars have different rates of development (IRGA 421 is a very early maturation genotype and EPAGRI 109 is a late maturation genotype). The cultivars were grown in two sowing dates (13/12/2006 and 16/01/2007) to have plants growing and developing under different temperature and photoperiod. The experimental design was a completely randomized, with four replications. In the pot experiment, the replication was a pot, and in the paddy rice, each plot was composed by four 1-m rows spaced 17cm. The pots site was about 500m away from the field plots.

Emergence (EM) was measured in each replication (pot or field plot) by counting the number of emerged plants on a daily basis. Date of EM was considered when 50% of the plants were emerged from the soil surface. Nitrogen, potassium and phosphorus application was done following the recommended rates for irrigated rice in Southern Brazil (SOSBAI, 2005), so nutrients availability to plants was not limiting. In the pot experiment, at V3 stage (three fully expanded leaves) of the COUNCE et al. (2000) scale, plants were thinned to 15 plants/pot, corresponding to a plant density of about 200 plants m^{-2}. The same plant density was used in the field plots. Irrigation was performed daily or as needed to keep a five to seven-cm water layer above soil surface (flooded soil) from V3 to R9 Counce stages in both pot-grown and field plants.

To measure growth and development parameters, five plants in the center of each pot and five plants in the central row of the field plots were tagged with colored wires, one week after emergence. The following growth parameters were measured: final (expanded) area of main stem leaves blade located on position number 5 (L5), 10 (L10) and the flag leaf, and final plant height, measured from soil surface to the end of the panicle. Development parameters evaluated included: Haun Stage (HS, leaves) (HAUN, 1973) at tillers (T1, T2, T3, and T4) appearance, HS at panicle differentiation (stage R1 of the

COUNCE Scale), and duration (°C day) of developmental phases EM – R1 and R1 – anthesis (R4).

Yield components (number of panicles per plant, number of kernels per panicle, number of sterile spikelets per panicle and dry weight of 100 kernels were measured on the tagged plants.

Daily minimum and maximum air temperature were measured by a standard meteorological station located about 200m away from the pots and about 600m from the field plots. Daily values of thermal time (TT, °C day) were calculated as follows (ARNOLD, 1960):

$$TT = (T - Tb) \cdot 1 \text{ day} \quad (2)$$

where T is the mean daily air temperature, calculated as the average of daily minimum and maximum air temperatures, and Tb is the base temperature, assumed as 11°C (INFELD et al., 1998; STRECK et al., 2007). The accumulated thermal time (ATT) from emergence was calculated by accumulating TT, i.e., $ATT = \sum TT$.

Statistical analysis was formed using analysis of variance (ANOVA), considering a two-factor experiment: factor A was the soil volume where plants were grown (pots and field plots) and factor B was the cultivar (IRGA 421 and EPAGRI 109). Means of growth and development parameters were distinguished by the F-test of two means. Pot-grown plants from the second sowing date had their main stem senesced at HS around 6.5 due to an unknown factor, and were not used for further measurements. Therefore, for this sowing date the variable measured were HS at tillers (T1, T2, T3, and T4) appearance, and area of L5 for both pot and field-grown plants.

Growth variables were significantly affected by restricting soil volume in the pot, except the area of the L10 leaf in EPAGRI 109 cultivar and the area of the flag leaf in cultivar IRGA 421 (Table 1). The area of leaves L5 and L10 was lower in the field-grown plants, where as area of the flag leaf and plant height were greater in the field-grown plants. These results agree in part with the results reported for wheat plants, where plants grown in small pots had lower area of the individual leaves and lower main stem height, but the higher area of the flag leaf in the pot-grown plants observed in this study are not in agreement with the results reported in PETERSON et al. (1984).

Most of the development variables were not affected by restricting soil volume (Table 2). For variables that were statistically different, the difference is not relevant from a practical standpoint. An example is the 0.4 leaves difference for the HS at T1 of EPAGRI 109 and 0.2 leaves difference for the HS at T2 of IRGA 421. These results agree with the ones reported in PETERSON et al. (1984) that wheat development was not affected by soil volume.

Yield components were not affected by restricting soil volume except number of panicles per plant (Table 3). Plants in the pots had twice as many panicles per plant compared to the field-grown plants. The greater number of panicles in pot-grown plants is probably due to the wide spacing among pots.

Table 1. Growth variables of two rice cultivars grown in pots and in field plots on two sowing dates. Santa Maria, RS, Brazil, 2006-2007.

Variable	Cultivar IRGA 421			Cultivar EPAGRI 109		
	Pot	Field	Sig[1]	Pot	Field	Sig[1]
	Sowing date: 13/12/2006					
Area of L5 blade (cm^2)	7.6	5.2	*	7.6	5.6	*
Area of L10 blade (cm^2)	40.9	35.7	*	30.3	27.5	ns
Area of flag leaf blade (cm^2)	31.3	33.7	ns	25.8	46.7	**
Plant height (cm)	54.5	67.9	**	60.5	74.8	**
	Sowing date: 16/01/2007					
Area of L5 blade (cm^2)	11.2	8.9	**	10.6	9.3	*

[1]Sig = significance: ns = F test not significant at P≤0.05, * = F test significant at P≤0.05, ** = t test significant at P≤0.01.

Table 2. Development variables of two rice cultivars grown in pots and in field plots in two sowing dates. Santa Maria, RS, Brazil, 2006-2007.

Variable	Cultivar IRGA 421			Cultivar EPAGRI 109		
	Pot	Field	Sig[1]	Pot	Field	Sig[1]
Sowing date: 13/12/2006						
HS at R1	9.4	10.3	**	12.9	13.5	*
Main stem final leaf number	11.5	12.3	ns	15.6	15.7	ns
Duration of EM-R1 phase (°C day)	470.0	510.4	ns	1017.5	1010.6	ns
Duration of R1-R4 phase (°C day)	328.2	339.1	ns	519,9	515,0	ns
Duration of R4-R9 phase (°C day)	381.5	584.3	**	---	---	---
Sowing date: 16/01/2007						
HS at tiller T1 appearance	5.2	5.3	ns	5.3	4.9	*
HS at tiller T2 appearance	4.8	4.6	*	4.6	4.7	ns
HS at tiller T3 appearance	5.6	5.5	ns	5.9	5.6	ns
HS at tiller T4 appearance	6.5	6.9	ns	6.6	6.3	ns

[1]Sig = significance: ns = F test not significant at P≤0.05, * = F test significant at P≤0.05, ** = F test significant at P≤0.01.

Table 3. Yield components of rice 'IRGA 421' cultivar grown in pots and in a field sown on 13/12/2006. Santa Maria, RS, Brazil.

Yield component	Pot	Field	Sig[1]
Number of panicles per plant	9.4	4.4	*
Number of filled kernels per panicle	78.0	78.5	ns
Number of sterile spikelets per panicle	26.3	34.0	ns
100 kernels dry weight (g) [2]	1.9	1.9	ns

[1]Sig = significance: ns = F test not significant at P≤0.05, * = F test significant at P≤0.05, ** = F test significant at P≤0.01. [2] Measured on the main stem panicle.

REFERENCES

ARNOLD, C.Y. Maximum-minimum temperatures as a basis for computing heat units. **Proceedings of the American Society for Horticultural Sciences**, v.76, p.682-692, 1960.

COUNCE, P.; KEISLING, T.C.; MITCHELL,A.J. A uniform, objective, and adaptive system for expressing rice development. **Crop Science**, v.40, p.438-443, 2000.

HAUN, J.R. Visual quantification of wheat development. **Agronomy Journal**, v.65, p.116-119, 1973.

INFELD, J.A.; SILVA, J.B.; ASSIS, F.N. Temperatura base e graus-dia durante o período vegetativo de três grupos de cultivares de arroz irrigado. **Revista Brasileira de Agrometeorologia**, v.6, p.187-191, 1998.

PETERSON, C.M.; KLEPPER, B.; PUMPHREY, F.V.; RICKMAN, R.W. Restricted rooting decreases tillering and growth of winter wheat. **Agronomy Journal**, v.76, p.861-863, 1984.

SOSBAI (Sociedade Sul Brasileira de Arroz irrigado). **Arroz irrigado: Recomendações técnicas para o sul do Brasil**. Santa Maria: SOSBAI, 2005.159p.

STRECK, N.A.; MICHELON, S.; ROSA, H.T.; WALTER, L.C.; BOSCO, L.C.; PAULA, G.M. de; CAMERA, C.; SAMBORANHA, F.K.; MARCOLIN, E.; LOPES, S.J. Filocrono de

genótipos de arroz irrigado em função de época de semeadura. **Ciência Rural**, v. 37, n. 2, p. 323-329, 2007.