SEMINA
Ciências Agrárias

DOI: 10.5433/1679-0359.2023v44n1p171

Optimal plot size in white oat with comparison of three methods

Tamanho ótimo de parcela em aveia branca com comparação de três métodos

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Highlights

We collected data from six uniformity trials with white oat.
We used three methods for determining the optimal plot size.
We provided information to improve experimental precision in white oat.

Abstract

The objective of this work was to compare three methods for estimating the optimal plot size to evaluate the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar. Six uniformity trials (blank experiments) were carried out, three trials on the first sowing date (May 3, 2021) and three trials on the second sowing date (May 26, 2021). Fresh matter productivity was evaluated in 216 basic experimental units (BEU) of 1 m × 1 m (36 BEU per trial). The BEU was formed by five rows of 1.0 m in length, spaced 0.20 m apart, totaling 1.0 m^2. The optimal plot size was determined using the methods of modified maximum curvature, linear response and plateau model and quadratic response and plateau model. The optimal plot size differs between the methods and decreases in the following order: quadratic response and plateau model (11.09 m^2), linear response and plateau model (7.65 m^2) and modified maximum curvature (4.00 m^2). The optimal plot size to evaluate the fresh matter productivity of white oat is 7.65 m^2 and the experimental precision stabilizes from this size on.

Key words: *Avena sativa* L. Experimental design. Linear response and plateau model. Quadratic response and plateau model. Modified maximum curvature.

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Received: Nov. 23, 2021 Approved: Feb. 28, 2023

Resumo

O objetivo deste trabalho foi comparar três métodos de estimação do tamanho ótimo de parcela para avaliar a produtividade de matéria fresca de aveia branca (*Avena sativa* L.), cultivar IPR Suprema. Foram conduzidos seis ensaios de uniformidade (experimentos em branco), sendo três na primeira data de semeadura (03 de maio de 2021) e três na segunda data de semeadura (26 de maio de 2021). Foi avaliada a produtividade de matéria fresca em 216 unidades experimentais básicas (UEB) de 1 m × 1 m (36 UEB por ensaio). A UEB foi formada por cinco fileiras de 1,0 m de comprimento, espaçadas 0,20 m entre fileiras, totalizando 1,0 m^2. Foi determinado o tamanho ótimo de parcela por meio dos métodos da curvatura máxima modificado, do modelo linear de resposta com platô e do modelo quadrático de resposta com platô. O tamanho ótimo de parcela difere entre os métodos e decresce na seguinte ordem: modelo quadrático de resposta com platô (11,09 m^2), modelo linear de resposta com platô (7,65 m^2) e curvatura máxima modificado (4,00 m^2). O tamanho ótimo de parcela para avaliar a produtividade de matéria fresca de aveia branca é 7,65 m^2 e a precisão experimental estabiliza a partir desse tamanho.

Palavras-chave: *Avena sativa* L. Curvatura máxima modificado. Dimensionamento experimental. Modelo linear de resposta com platô. Modelo quadrático de resposta com platô.

Introduction

White oat (*Avena sativa* L.), belongs to the Poaceae family. Cultivated in winter for the production of forage, hay, silage and grain. It has good biomass production and improves the physical and biological aspects of the soil. The largest productions are concentrated in the states of the South and Southeast of Brazil (Carvalho et al., 2022).

When planning experiments with agricultural crops such as white oat (*Avena sativa* L.), it is important to know soil spatial and temporal variability in the experimental area and size the plot size. Adequate sizing of plot size allows minimizing the experimental error and, consequently, increasing the reliability of inferences in relation to the evaluated treatments, besides optimizing the resources involved in the study, such as labor, time, financial resources and experimental area (Storck et al., 2016).

The minimization of experimental error is due to the fact that the coefficient of variation decreases gradually and non-linearly, with the increment in plot size. This response pattern makes it possible to use methods for determining the optimal plot size in datasets obtained in uniformity trials (blank experiments) (Storck et al., 2016).

With these datasets, it is possible to plan different plot sizes (X) by grouping adjacent basic experimental units (BEU) and estimate the coefficient of variation ($CV_{(X)}$, in %) between BEU. The values of $CV_{(X)}$ as a function of X can be related by the methods of modified maximum curvature (MMC) (Meier & Lessman, 1971), linear response and plateau model (LRP) (Paranaíba et al., 2009) and quadratic response and plateau model (QRP) (Peixoto et al., 2011), and make it possible to determine the optimal plot size (Xo) and the coefficient of variation in the optimal plot size (CV_{Xo}).

Comparative studies involving the MMC and LRP methods have been carried out with papaya (Brito et al., 2012), pineapple (Leonardo et al., 2014), cabbage (Guarçoni et al., 2017) and cassava (Sousa et al., 2018), the LRP e QRP methods with passion fruit (Peixoto et al., 2011) and MMC, LRP and QRP methods with radish (Silva et al., 2012), sweet potato (González et al., 2018), cactus pear (Guimarães et al., 2019), coffee (Moreira et al., 2016, Brioschi et al., 2020), millet + slender leaf rattlebox + showy rattlebox (Cargnelutti et al., 2021a) and buckwheat (Cargnelutti et al., 2021b), evidencing distinct results between the methods and the importance of using more than one method to determine the optimal plot size.

Plot size has been investigated to evaluate the fresh matter of black oat (Cargnelutti et al., 2014), grain yield of white oat (Lavezo et al., 2017) and fresh and dry matter of white oat (Lavezo et al., 2018), by means of the maximum curvature method of the coefficient of variation model (Paranaíba et al., 2009). Plot size has also been determined for the evaluation of fresh matter in intercropping of black oat with common vetch (Cargnelutti et al., 2020), through the methodologies of Smith (1938) and Hatheway (1961). However, the MMC, LRP and QRP methods were not used in these studies. It is assumed that the use of these methods, in new uniformity trials and with another white oat cultivar not explored in previous studies, can generate different plot sizes and, therefore, aggregate important information for planning experiments with white oat crop, aiming at greater experimental precision.

Thus, the objective of this work was to compare three methods for estimating the optimal plot size to evaluate the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar.

Material and Methods

These uniformity trails (blank experiments) were conducted with white oat (*Avena sativa* L.), IPR Suprema cultivar, in an experimental area located at 29º42'S, 53º49'W and 95 m altitude. In this place, the climate is humid subtropical Cfa (Alvares et al., 2013) and the soil is *Argissolo Vermelho distrófico arênico* (Ultisol) (Santos et al., 2018).

The cultivar IPR Suprema was sown on two dates (May 3, 2021 and May 26, 2021). Three uniformity trials were set up on each sowing date. In the six trials, mechanized sowing was performed in rows, spaced 0.20 m apart, by placing 60 kg of seeds ha^{-1}. Basal fertilization consisted of 35 kg ha^{-1} of N, 135 kg ha^{-1} of P_2O_5 and 135 kg ha^{-1} of K_2O and, subsequently, two top-dressing fertilizations of 41 kg ha^{-1} of N were performed in the development stages V3 (three expanded leaves) and V6 (six expanded leaves). The necessary cultural practices were carried out to keep the crop free of pests, diseases and weeds.

In each uniformity trial, an area 6 m × 6 m (36 m^2) was demarcated and divided into 36 basic experimental units (BEU) of 1 m × 1 m (1 m^2), forming a matrix of six rows and six columns. The BEU was formed by five rows of 1.0 m in length, spaced 0.20 m apart, totaling 1.0 m^2.

Fresh material productivity (FM, in g m^{-2}) evaluations were carried out on October 7, 2021 and October 8, 2021, in the trails installed on May 3, 2021, and on May 26, 2021, that is, 157 and 135 days after sowing, respectively. On these dates, the white oat was in the vegetative period, that is, in the development stages V10 and V8 for the trials set up, respectively, on May 3, 2021, and on May 26, 2021. For these evaluations, in each 1 m^2 BEU, the plants were cut close to the soil surface and fresh matter was weighed on a digital scale (accuracy: 1 g), obtaining fresh matter productivity (FM, in g m^{-2}) in 216 BEU (6 trials × 36 BEU per trial).

For each uniformity trial, the FM data of the 36 BEU were used to plan plots with X_R BEU adjacent in the row and X_C BEU adjacent in the column. Plots with different sizes and/or shapes were planned as being ($X=X_R \times X_C$), that is, (1×1), (1×2), (1×3), (1×6), (2×1), (2×2), (2×3), (2×6), (3×1), (3×2), (3×3), (3×6), (6×1), (6×2) and (6×3). The acronyms X_R, X_C and X mean, respectively, number of BEU adjacent in the row, number of BEU adjacent in the column, and plot size in number of BEU. For each plot size (X), the following parameters were determined: n - number of plots with X BEU in size (n=36/X); $M_{(X)}$ - mean of plots with X BEU in size; and $CV_{(X)}$ - coefficient of variation (in %) between plots with X BEU in size.

For each trial, the optimal plot size (Xo) was determined using the methods of modified maximum curvature (MMC) (Meier & Lessman, 1971), linear response and plateau model (LRP) (Paranaíba et al., 2009) and quadratic response and plateau model (QRP) (Peixoto et al., 2011). In these three methods, models of the dependent variable ($CV_{(X)}$, in %) are fitted as a function of the independent variable (X, in BEU). The average $CV_{(X)}$ between the plots with the same size, but different shapes, was used in the fit of the models.

In the MMC method, parameters *a* and *b* and the coefficient of determination (R^2) of the model $CV_{(X)} = a/X^b + \varepsilon$ were estimated. Xo was determined by the expression: $Xo = [a^2 b^2 (2b + 1) / (b+2)]^{(1/(2b+2))}$. The coefficient of variation corresponding to the optimal plot size (CV_{Xo}) was determined by $CV_{Xo} = a/Xo^b$.

For the LRP model, two segmented lines were fitted and the parameters *a*, *b* and *p* and the coefficient of determination (R^2) were estimated. The first line ($CV_{(X)} = a + bX + \varepsilon$) was fitted up to the point corresponding to Xo, with angular coefficient (*b*) different from zero. The second line ($CV_{(X)} = p + \varepsilon$) starts from Xo and has angular coefficient equal to zero (line parallel to the abscissa), where *p* = plateau, that is, p corresponds to CV_{Xo}. The LRP model was as follows: $CV_{(X)} = \begin{cases} a + bX + \varepsilon & if\ X \le Xo \\ p + \varepsilon & if\ X > Xo \end{cases}$. In the LRP model, $Xo = (p-a)/b$ and $CV_{Xo} = a + bXo$.

For the QRP model, the fit was performed using two segmented equations. Estimates of parameters a, b, c and p and the coefficient of determination (R^2) were obtained. The quadratic part of the model was fitted up to the Xo point ($CV_{(X)} = a + bX + cX^2 + \varepsilon$). After Xo, the model turns into a zero-slope line, called plateau, whose model is described by ($CV_{(X)} = p + \varepsilon$), where *p* = plateau, that is, $p = CV_{Xo}$. Thus, the QRP model was as follows: $CV_{(X)} = \begin{cases} a + bX + cX^2 + \varepsilon & if\ X \le Xo \\ p + \varepsilon & if\ X > Xo \end{cases}$. In the QRP model, $Xo = -b / 2c$ and $CV_{Xo} = a - b^2 / 4c$. In the LRP and QRP models, the point of union between the two segments corresponds to Xo in the abscissa and CV_{Xo} in the ordinate. In the three models (MMC, LRP and QRP), ε is the residual or random error.

For the six uniformity trials, fresh matter productivity (FM, g m^{-2}), the coefficient of variation of the trial (CV, %) and the estimates of the coefficient of determination (R^2), optimal plot size (Xo) and coefficient of variation in the optimal plot size (CV_{Xo}, %), in relation to the methods MMC, LRP and QRP, were obtained. The comparisons of means of the estimates of R^2, Xo and CV_{Xo} between the methods (MMC *versus* LRP, MMC *versus* QRP and LRP *versus* QRP), regardless of sowing date (n = 6 uniformity trials), were performed by Student's t-test (two-tailed), for dependent samples, at 5% significance level. The results of these comparisons were represented by letters next to the means. Statistical analyses were performed with the Microsoft Office Excel® application and R software (R Development Core Team [R], 2021).

Results and Discussion

The fresh matter productivity (FM) of white oat (*Avena sativa* L.), IPR Suprema cultivar, ranged from 3031 g m^{-2} to 3393 g m^{-2}, with an average of 3177 g m^{-2} among the six uniformity trials, which is equivalent to 31.77 Mg ha^{-1} (Table 1). The average FM on the second sowing date (3283 g m^{-2}) was higher than on the first sowing date (3070 g m^{-2}) (t = 3.1201; p-value = 0.035524, 4 degrees of freedom). This lower productivity at the first sowing date is possibly due to the senescence of leaves at the time of evaluation, because it was performed at 157 days after sowing (DAS), while on the second sowing date the evaluation was performed at 135 DAS.

Based on the FM data of the 36 basic experimental units (BEU) of 1 m × 1 m (1 m^2), the coefficients of variation (CV) ranged between 17.00% and 22.30%, with an average of 19.86%. Taking as reference the classification ranges of the coefficients of variation established by Pimentel-Gomes (2009) for field agricultural trials, three CVs were within the class of medium experimental precision (10% < CV ≤ 20%) and three were within the class of low experimental precision (20% < CV ≤ 30%) (Tables 1 and 2). The mean CVs of the three trials set up on the first sowing date (18.77%) did not differ from the mean of the three trials set up on the second sowing date (20.96%) (t = 1.2075; p-value = 0.293763, 4 degrees of freedom). This suggests similar plot size between the sowing dates.

In these trials, the evaluation of FM was carried out in basic experimental units of 1 m^2. In order to improve experimental precision, it is possible to use larger plots. This finding is confirmed by the nonlinear decrease in the coefficient of variation [$CV_{(X)}$], with the increase in the planned plot size (X) (Table 1, Figures 1, 2 and 3). There is also a trend of stabilization of $CV_{(X)}$, which points to the importance of using the MMC, LRP and QRP methods to determine the optimal plot size.

Table 1

Planned plot size ($X=X_R \times X_C$), in basic experimental units (BEU), with X_R BEU adjacent in the row and X_C BEU adjacent in the column; number of plots with X BEU in size (n=36/X); mean of plots with X BEU in size [$M_{(X)}$], in g; coefficient of variation (in %) between the plots with X BEU in size [$CV_{(X)}$]; and mean of the coefficient of variation (in %) between the plots of X BEU with the same size, but different shapes [$CV_{(X)}$]. Data of fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar, obtained in uniformity trials [(1)] conducted on two sowing dates

Sowing	X_R	X_C	X	n	$M_{(X)}$	$CV_{(X)}$	$CV_{(X)}$ [(2)]	$M_{(X)}$	$CV_{(X)}$	$CV_{(X)}$ [(2)]	$M_{(X)}$	$CV_{(X)}$	$CV_{(X)}$ [(2)]
						Trial 1			Trial 2			Trial 3	
05/03/2021	1	1	1	36	3060.21	17.00	17.00	3120.18	22.01	22.01	3030.89	17.29	17.29
05/03/2021	1	2	2	18	6120.42	14.20	14.01	6240.36	18.07	18.24	6061.78	13.45	14.03
05/03/2021	2	1	2	18	6120.42	13.82	-	6240.36	18.41	-	6061.78	14.60	-
05/03/2021	1	3	3	12	9180.63	5.84	9.28	9360.54	11.57	14.18	9092.67	8.90	11.05
05/03/2021	3	1	3	12	9180.63	12.72	-	9360.54	16.79	-	9092.67	13.21	-
05/03/2021	2	2	4	9	12240.83	11.73	11.73	12480.72	17.02	17.02	12123.56	12.69	12.69
05/03/2021	1	6	6	6	18361.25	3.22	7.30	18721.08	8.70	12.12	18185.33	6.98	9.54
05/03/2021	2	3	6	6	18361.25	2.41	-	18721.08	9.53	-	18185.33	6.48	-
05/03/2021	3	2	6	6	18361.25	11.12	-	18721.08	15.13	-	18185.33	11.97	-
05/03/2021	6	1	6	6	18361.25	12.43	-	18721.08	15.11	-	18185.33	12.74	-
05/03/2021	3	3	9	4	27541.88	1.80	1.80	28081.63	6.82	6.82	27278.00	4.41	4.41
05/03/2021	2	6	12	3	36722.50	1.23	6.75	37442.17	5.99	10.16	36370.67	5.71	8.92
05/03/2021	6	2	12	3	36722.50	12.27	-	37442.17	14.32	-	36370.67	12.13	-
05/03/2021	3	6	18	2	55083.75	1.35	0.83	56163.25	0.46	4.00	54556.00	4.75	3.17
05/03/2021	6	3	18	2	55083.75	0.31	-	56163.25	7.54	-	54556.00	1.60	-
						Trial 1			Trial 2			Trial 3	
05/26/2021	1	1	1	36	3279.45	22.30	22.30	3393.35	19.50	19.50	3175.83	21.07	21.07
05/26/2021	1	2	2	18	6558.90	16.95	17.93	6786.69	14.85	15.55	6351.66	15.84	17.56
05/26/2021	2	1	2	18	6558.90	18.90	-	6786.69	16.26	-	6351.66	19.28	-
05/26/2021	1	3	3	12	9838.35	15.74	16.59	10180.04	11.63	11.74	9527.48	9.72	13.67
05/26/2021	3	1	3	12	9838.35	17.44	-	10180.04	11.85	-	9527.48	17.62	-
05/26/2021	2	2	4	9	13117.80	15.01	15.01	13573.39	11.04	11.04	12703.31	14.41	14.41
05/26/2021	1	6	6	6	19676.70	11.56	13.64	20360.08	7.07	8.86	19054.97	5.14	11.01
05/26/2021	2	3	6	6	19676.70	13.40	-	20360.08	9.95	-	19054.97	7.89	-
05/26/2021	3	2	6	6	19676.70	14.81	-	20360.08	7.73	-	19054.97	13.93	-
05/26/2021	6	1	6	6	19676.70	14.79	-	20360.08	10.70	-	19054.97	17.09	-
05/26/2021	3	3	9	4	29515.05	13.04	13.04	30540.13	8.98	8.98	28582.45	8.31	8.31
05/26/2021	2	6	12	3	39353.40	9.16	10.84	40720.17	5.00	5.90	38109.93	3.42	8.80
05/26/2021	6	2	12	3	39353.40	12.52	-	40720.17	6.81	-	38109.93	14.18	-
05/26/2021	3	6	18	2	59030.10	11.90	10.56	61080.25	1.39	5.71	57164.90	4.30	6.67
05/26/2021	6	3	18	2	59030.10	9.23	-	61080.25	10.04	-	57164.90	9.04	-

[(1)] Each uniformity trial with size of 6 m × 6 m (36 m^2) was divided into 36 BEU of 1 m × 1 m (1 m^2), forming a matrix of six rows and six columns. [(2)] Average $CV_{(X)}$ between plots with the same size, but different shapes, used in the fit of the models.

The coefficients of determination (R^2) among the six uniformity trials ranged from 0.81 to 0.99, 0.83 to 0.94, and 0.83 to 0.96, for the methods of modified maximum curvature (MMC), linear response and plateau model (LRP) and quadratic response and plateau model (QRP), respectively (Table 2, Figures 1, 2 and 3). It is considered that $0.00 \leq R^2 \leq 1.00$, and it is interpreted that the closer to 1.00, the better the fit of the model to the data (Storck et al., 2016). In the comparisons of the methods, regardless of the sowing date, the means of R^2 were 0.90, 0.88 and 0.90, for the MMC, LRP and QRP methods, respectively, and do not differ from each other. It is considered that the three methods showed R^2 close to one ($R^2 \geq 0.88$), giving credibility to the estimates of Xo and CV_{Xo}, calculated from these models.

The optimal plot sizes (Xo), among the six uniformity trials, were higher in the QRP method ($7.78 \leq Xo \leq 18.22$ m^2), intermediate in LRP ($6.37 \leq Xo \leq 8.82$ m^2) and lower in MMC ($3.44 \leq Xo \leq 4.47$ m^2) (Table 2, Figures 1, 2 and 3). The Xo differed among the three methods, being 11.09 m² by QRP, 7.65 m^2 by LRP and 4.00 m^2 by MMC. Thus, it can be inferred that plot size depends on the estimation method.

The coefficients of variation in the optimal plot size (CV_{Xo}, in %), among the six uniformity trials, varied from 8.32 to 15.89%, 3.13 to 11.48%, and 3.31 to 11.60% for the MMC, LRP and QRP methods, respectively (Table 2, Figures 1, 2 and 3). The CV_{Xo} was higher in MMC (11.82%) compared to LRP (6.98%) and QRP (6.72%), which did not differ from each other. These results, according to the classification of Pimentel-Gomes (2009), indicate high experimental precision with the use of plot sizes determined by the LRP and QRP ($CV \leq 10\%$) methods and medium precision with MMC ($10\% < CV \leq 20\%$).

The three methods showed means of R^2 close to one ($R^2 \geq 0.88$). The means of Xo were decreasing in the following order: QRP = 11.09 m^2; LRP = 7.65 m^2; and MMC = 4.00 m^2. CV_{Xo} was higher in MMC (11.82%) and there was no difference between LRP (6.98%) and QRP (6.72%). Therefore, although the plot sizes are different between the LRP (7.65 m^2) and QRP (11.09 m^2) methods, they result in similar experimental precision, since the CV_{Xo} did not differ. This absence of difference is explained by the fact that, from a given plot size, the gains in precision (decrease in the coefficient of variation) with the increment in plot area are insignificant (Figures 1, 2 and 3). Then, it can be inferred that plots with 7.65 m^2 are suitable for experimental planning. This indication of plots of 7.65 m² is supported by practical feasibility in the field and stabilization of precision from this size and can be used as a reference for planning future experiments.

Table 2

Fresh matter productivity (FM, in g m-2), coefficient of variation (CV, in %), estimates of parameters *a*, *b* and *c*, coefficient of determination (R^2), optimal plot size (Xo, in m²) and coefficient of variation in optimal plot size (CV_{Xo}, in %), in relation to the methods of modified maximum curvature (MMC), linear response and plateau model (LRP) and quadratic response and plateau model (QRP), obtained from the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar, evaluated on two sowing dates

Sowing	Trial (1)	FM (g m-2)	CV (%)	*a*	*b*	*c*	R^2	Xo (m²)	CV_{Xo} (%)
						MMC			
05/03/2021	1	3060	17.00	18.245	0.551	-	0.81	4.16	8.32
05/03/2021	2	3120	22.01	23.261	0.408	-	0.85	4.47	12.63
05/03/2021	3	3031	17.29	18.063	0.409	-	0.82	3.74	10.52
05/26/2021	1	3279	22.30	22.021	0.264	-	0.99	3.44	15.89
05/26/2021	2	3393	19.50	19.773	0.427	-	0.98	4.06	10.88
05/26/2021	3	3176	21.07	21.706	0.379	-	0.97	4.13	12.67
Mean		3177	19.86				0.90 a	4.00 c	11.82 a
						LRP			
05/03/2021	1	3060	17.00	17.540	-1.774	-	0.86	8.12	3.13
05/03/2021	2	3120	22.01	22.250	-1.730	-	0.87	8.82	6.99
05/03/2021	3	3031	17.29	17.289	-1.365	-	0.83	8.63	5.50
05/26/2021	1	3279	22.30	22.213	-1.600	-	0.91	6.71	11.48
05/26/2021	2	3393	19.50	19.885	-2.045	-	0.90	6.37	6.87
05/26/2021	3	3176	21.07	21.555	-1.878	-	0.94	7.25	7.93
Mean		3177	19.86				0.88 a	7.65 b	6.98 b
						QRP			
05/03/2021	1	3060	17.00	19.523	-3.040	0.142	0.85	10.67	3.31
05/03/2021	2	3120	22.01	22.119	-1.899	0.052	0.88	18.22	4.82
05/03/2021	3	3031	17.29	19.007	-2.413	0.109	0.83	11.05	5.67
05/26/2021	1	3279	22.30	24.194	-2.958	0.174	0.94	8.52	11.60
05/26/2021	2	3393	19.50	22.737	-4.038	0.260	0.94	7.78	7.03
05/26/2021	3	3176	21.07	23.093	-2.958	0.144	0.96	10.29	7.88
Mean		3177	19.86				0.90 a	11.09 a	6.72 b

(1) Each uniformity trial of size 6 m × 6 m (36 m²) was divided into 36 BEU of 1 m × 1 m (1 m²), forming a matrix of six rows and six columns. Means of R^2, Xo and CV_{Xo} not followed by the same lowercase letter in the column (comparison of methods) differ at 5% significance level by the Student's t-test (two-tailed), for dependent samples with five degrees of freedom.

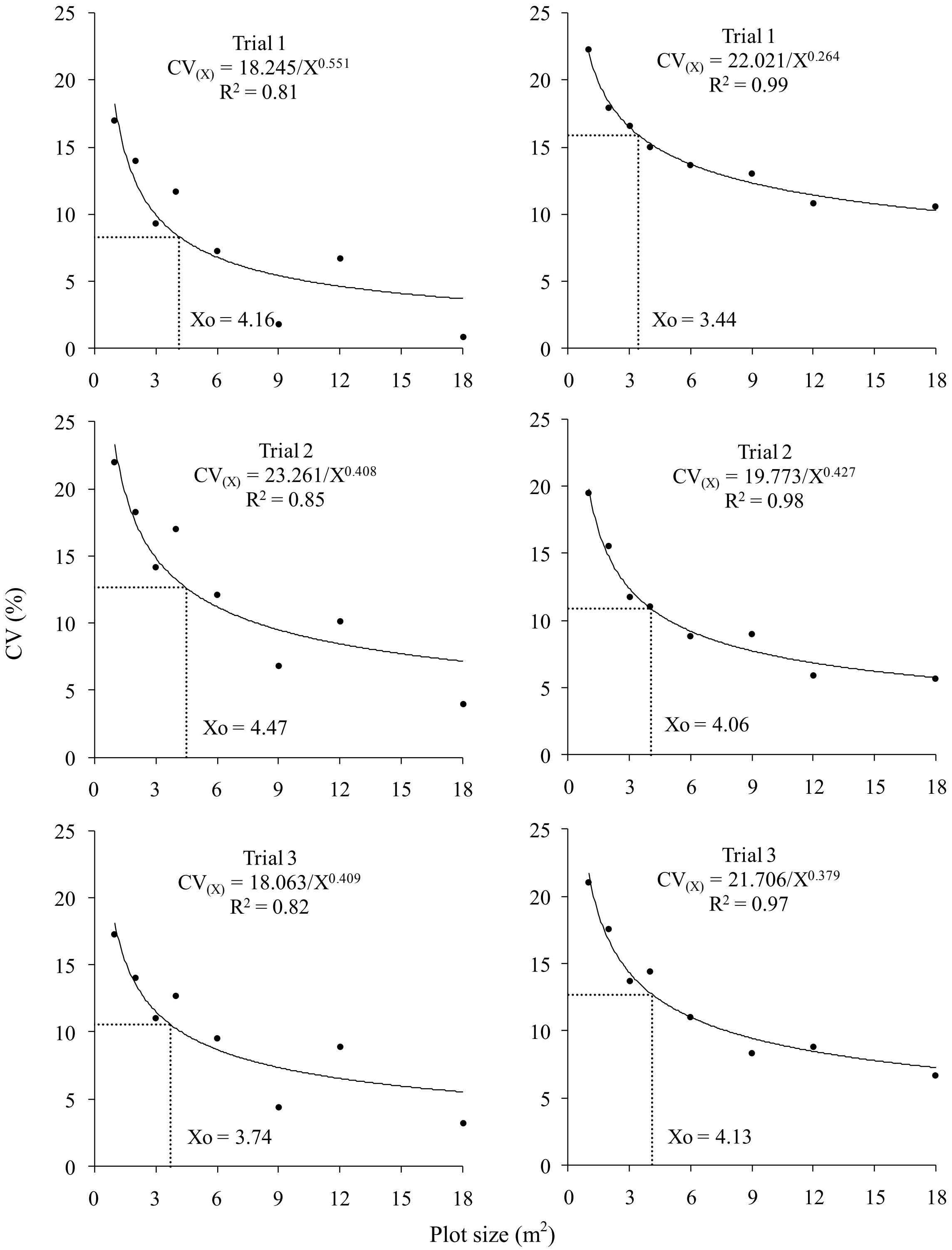

Figure 1. Representation of the optimal plot size (Xo, in m²) and coefficient of variation in the optimal plot size (CV_{Xo}, in %), obtained by the modified maximum curvature method (MMC), in relation to the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar, sown on 05/03/2021 (three trials of the left column) and 05/26/2021 (three trials of the right column).

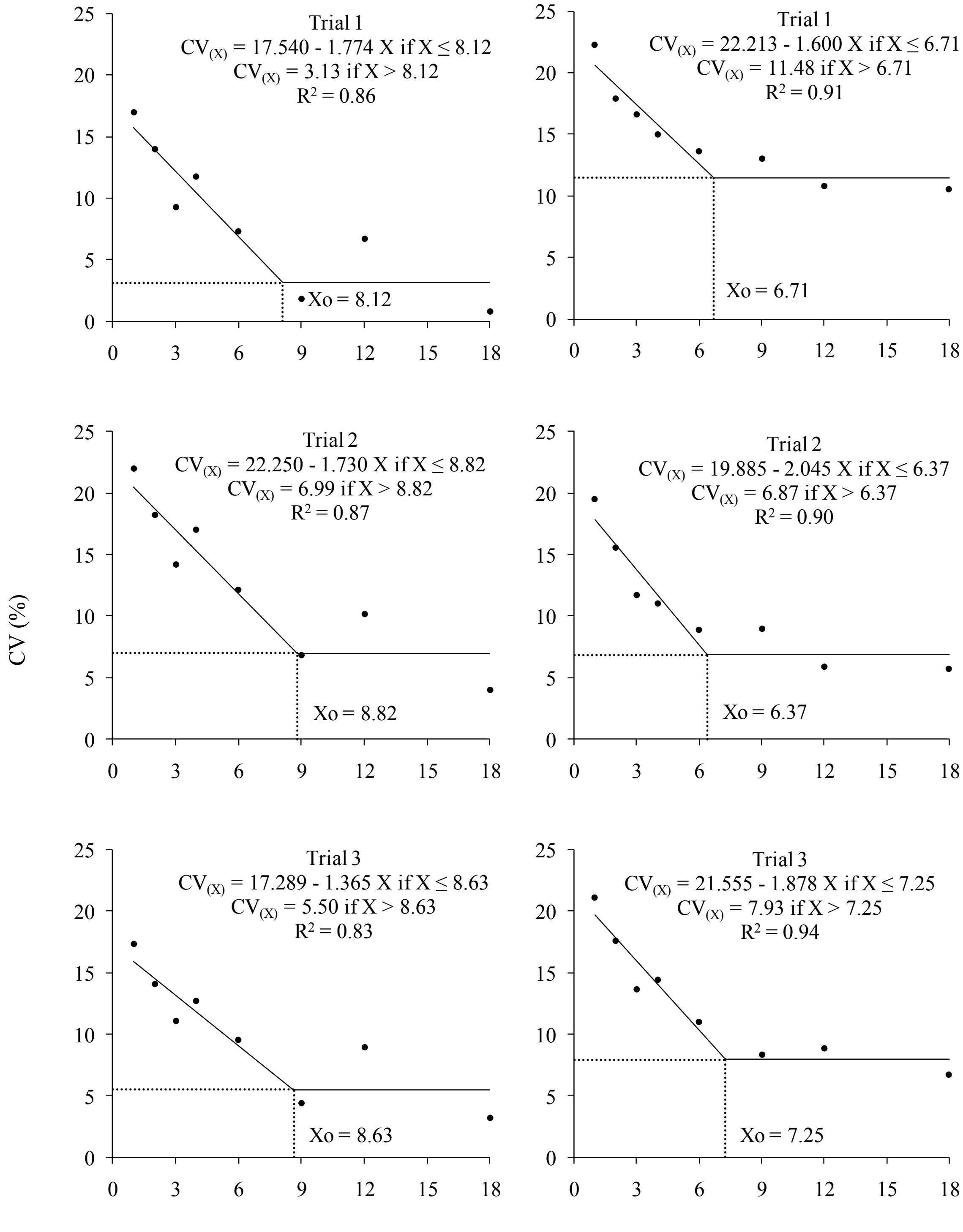

Figure 2. Representation of the optimal plot size (Xo, in m^2) and coefficient of variation in optimal plot size (CV_{Xo}, in %), obtained by the linear response and plateau model (LRP), in relation to the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar, sown on 05/03/2021 (three trials of the left column) and 05/26/2021 (three trials of the right column).

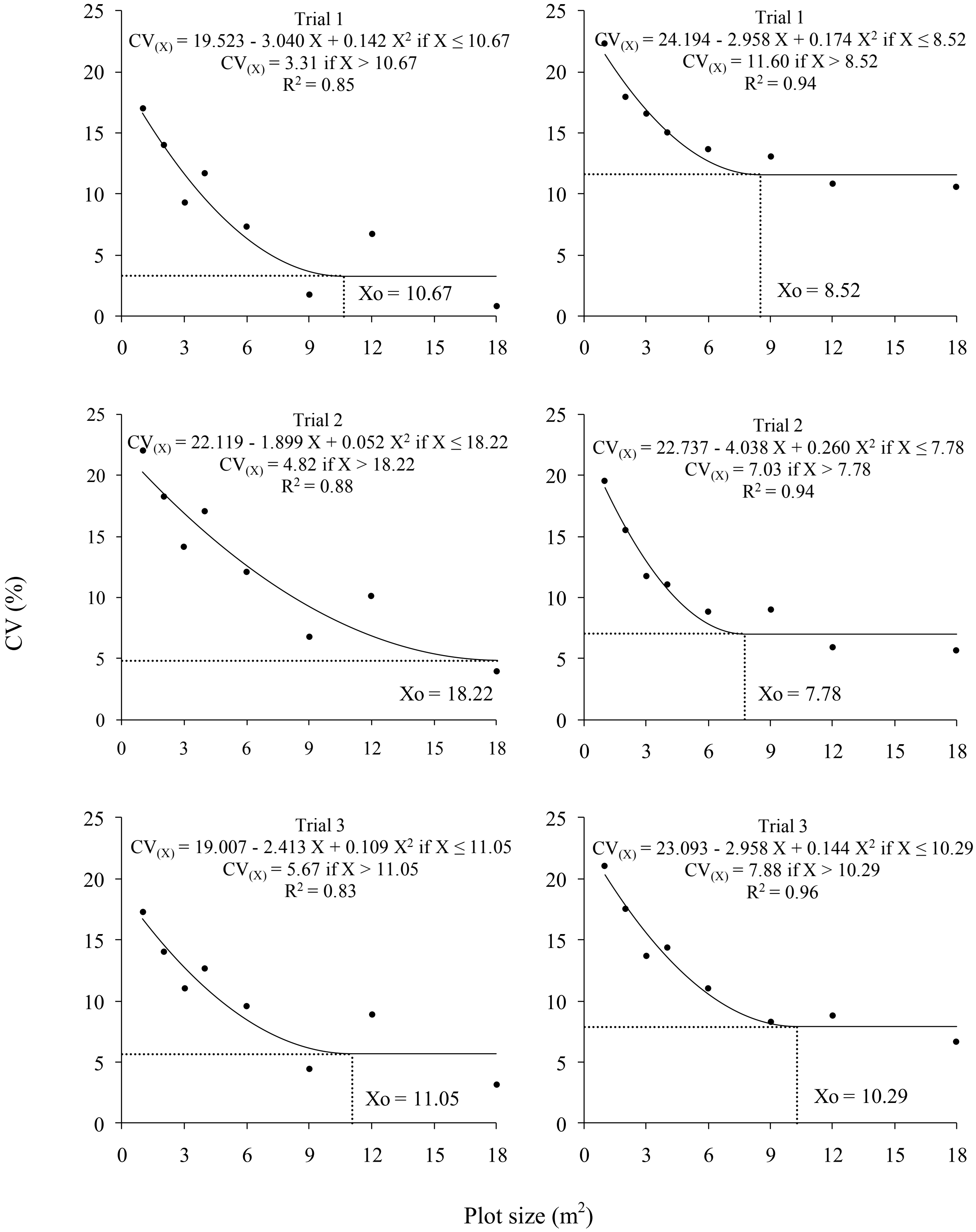

Figure 3. Representation of the optimal size (Xo, in m^2) and coefficient of variation in the optimal plot size (CV_{Xo}, in %), obtained by the quadratic response and plateau model (QRP), in relation to the fresh matter productivity of white oat (*Avena sativa* L.), IPR Suprema cultivar, sown on 05/03/2021 (three trials of the left column) and 05/26/2021 (three trials of the right column).

Based on the method of maximum curvature of the coefficient of variation model (Paranaíba et al., 2009), the following plot sizes were determined: 4.14 m² to evaluate the fresh matter of black oat (Cargnelutti et al., 2014); 1.57 m² for grain yield of white oat (Lavezo et al., 2017) and 1.66 m^2 and 1.73 m^2, respectively, for fresh and dry matter of white oat (Lavezo et al., 2018). Using the methodologies of Smith (1938) and Hatheway (1961), the plot size determined for the evaluation of fresh matter in intercropping of black oat with common vetch was 10 m^2 (Cargnelutti et al., 2020). Therefore, the plot size of 7.65 m2, necessary to evaluate the fresh matter productivity of white oat, is intermediate compared to those presented by these authors. However, the comparisons of the results should be analyzed with caution due to the different methods used to determine the plot size, environmental differences, different managements of uniformity trials, different sizes of the basic experimental units, different cultivars and variables analyzed.

Studies have shown decreasing estimates of Xo in the following order: QRP, LRP and MMC (Silva et al., 2012; Moreira et al., 2016; González et al., 2018; Guimarães et al., 2019; Cargnelutti et al., 2021a,b); higher estimates of Xo by QRP compared to LRP (Peixoto et al., 2011); and higher estimates of Xo by LRP compared to MMC (Brito et al., 2012; Leonardo et al., 2014; Guarçoni et al., 2017; Sousa et al., 2018; Brioschi et al., 2020).

Therefore, in these studies with the approach of comparing methods to determine the optimal plot size, results similar to those of the present study were found. This highlights the importance of using different methods and possible underestimation of the plot size determined by the MMC, overestimation by the QRP method and adequacy by the LRP method. However, it is important to conduct more studies similar to this, with other variables (example: grain yield, dry matter productivity), crops and methods before defining the ideal method for determining the optimal plot size.

Conclusions

The optimal plot size differs between the methods and decreases in the following order: quadratic response and plateau model (11.09 m^2), linear response and plateau model (7.65 m²) and modified maximum curvature (4.00 m²). The optimal plot size to evaluate the fresh matter productivity of white oat is 7.65 m^2 and the experimental precision stabilizes from this size.

Acknowledgments

To the National Council for Scientific and Technological Development (CNPq - Processes 304652/2017-2; 159611/2019-9; 146258/2019-3), the Coordination for the Improvement of Higher Education Personnel (CAPES) and the Rio Grande do Sul State Research Support Foundation (FAPERGS) for granting scholarships. To scholarship-holding students and volunteers for their assistance in data collection.

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