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Full Length Research Paper

Influence of Basic Experimental Unit (BEU) for the evaluation of fresh matter of sunn hemp (C. juncea L.)

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The influence of the basic experimental unit size on the plot size estimation determined by the method of maximum curvature of the coefficient of variation model is unknown in sunn hemp. This study aimed to verify the influence of the basic experimental unit (BEU) size in the estimate of the optimum plot size obtained by the method of maximum curvature of the coefficient of variation model for the evaluation of fresh matter of sunn hemp (*Crotalaria juncea* L.). Fresh matter of sunn hemp at the flowering was evaluated in uniformity trials in two sowing dates. In each sowing date, 4,608 BEU of 0.5 × 0.5 m (0.25 m^2) were evaluated and 64 BEU plans were formed with sizes from 0.25 to 64 m^2. In each evaluation period for each BEU plan, the first order spatial autocorrelation coefficient, variance, standard deviation, mean, coefficient of variation of the trial and the plot size were determined with the fresh matter data. For each BEU plan, the optimum plot size was determined by the method of maximum curvature of the coefficient of variation model. The estimate of optimum plot size depends on the basic experimental unit size. Determining the plot size to assess the fresh matter in basic experimental units as small as possible is recommended in order to prevent overestimation of the plot size and to contemplate all existing variability.

Key words: *Crotalaria juncea* L.*,* experimental design, basic experimental unit.

INTRODUCTION

The sunn hemp (Crotalaria juncea L.) is a cover crop matter production and nitrogen fixation (Silva and option for soil protection due to its hardiness, high dry Menezes, 2007), improving and maintaining soil quality, raising to considerable levels of soil organic matter and nutrients (Leite et al., 2010). The crop rapid development enables the use of sunn hemp in cropping systems with rotation and crop succession. It is the legume with greatest dry matter production in comparison with gray velvet bean (Mucuna nivea), jack bean (Canavalia ensiformis), velvet bean (Mucuna aterrina), lab-lab (Dolichos lablab), showy crotalaria (Crotalaria spectabilis), and dwarf pigeon pea (Cajanus cajan) (Teodoro et al., 2011); in a study carried out by Andrade Neto et al. (2010), the fresh matter of aerial part values of sunn hemp were 13.9 t ha-1.

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One aspect to be considered is the inferences made in agricultural research representing experimental reality which is the use of an optimum plot size to minimize the experimental error. The optimum plot size can be calculated based on data obtained from uniformity trials in which treatments are not applied (Ramalho et al., 2012; Storck et al., 2016). In order to evaluate traits of the studied crop, the experimental area is divided into basic experimental units (BEU) with the smallest possible size. Therefore, based on this information, the plot size is determined.

The influence of the BEU size in estimating the optimum plot size is still an area with few studies but Oliveira et al. (2005) verified in potato (*Solanum tuberosum* L.) the BEU size effect on the optimum plot size estimated by the method of the modified maximum curvature (Meier and Lessman, 1971). These authors also concluded that the BEU size interferes with estimating the optimum plot size. In maize (*Zea mays* L.), Storck et al. (2006a) identified the causes of variation in the estimates of the optimum plot sizes obtained by different methods and concluded that estimate of variance among plots of one BEU and the soil heterogeneity index interfere with optimum plot size. Thus, the optimum plot size depends on the BEU size.

In white lupine (*Lupinus albus* L.) and forage turnip (*Raphanus sativus*), the BEU size affects the estimate of the plot size, which evaluate the fresh matter in BEU as small as possible in order to be used in the estimation of the optimum plot size (Cargnelutti Filho et al., 2016a, b). Several methodologies are used to estimate the optimum plot size. The method of maximum curvature of the coefficient of variation model (Paranaíba et al., 2009a) is considered appropriate to obtain the optimum plot size of wheat and cassava (Paranaíba et al., 2009b). This method presents the advantage of dispensing the grouping of adjacent BEU, that is, the researcher should only get estimates of first order spatial autocorrelation coefficient, variance and mean based on a plot with size equals to one BEU.

Estimates of the plot size by the method of Paranaíba et al. (2009a) were performed for several crops, such as the study of fresh matter of forage turnip (*Raphanus sativus* L.) (Cargnelutti Filho et al., 2014b); fresh matter of black oat (*Avena strigosa* Schreb) (Cargnelutti Filho et al., 2014a); fresh matter of pods, fresh matter of aerial part without pods, and fresh matter of aerial part of jack bean (*Canavalia ensiformis*) (Cargnelutti Filho et al., 2014c); fresh matter of canola (*Brassica napus* L.) (Cargnelutti Filho et al., 2015); fresh matter of pigeon pea (*Cajanus cajan* (L.) Millsp.) (Santos et al., 2016); fresh matter of lettuce (*Lactuca sativa*), and fresh matter of pepper fruits (*Capsicum annuum*) (Schwertner et al., 2015).

Studies on the influence of the BEU size in estimating plot size obtained by the method of maximum curvature of the coefficient of variation model (Paranaíba et al., 2009a) for sunn hemp crop were not found in literature. Therefore, the hypothesis that the BEU size influences the determination of plot size is unknown for the sunn hemp crop.

Thus, this study aimed to verify the influence of the basic experimental unit (BEU) size in the estimate of the optimum plot size obtained by the method of maximum curvature of the coefficient of variation model for the evaluation of fresh matter of sunn hemp (*C. juncea* L.).

MATERIALS AND METHODS

Two uniformity trials were carried out with sunn hemp (*C. juncea* L.) in an experimental area of 50 × 52 m located in southern Brazil at 29°42'S lat, 53°49'W long, and 95 m of altitude. According to Köppen climate classification, the climate is *Cfa*, humid subtropical, with hot summers and no dry season defined (Heldwein et al., 2009) (Figure 2). The soil is classified as sandy loam typic Paleudalf (Santos et al., 2013).

The experiment was performed during the 2014/15 agricultural year in two sowing dates. In the first sowing date, the sowing procedure was held on 22 October, 2014 and in the second sowing date, the sowing procedure was held on December 03, 2014 (Figure 2). The sowing for both sowing dates was performed in rows with spacing of 0.50 m, with plant density of 20 plants per linear meter in an area of 50 × 26 m (1,300 m^2). The basic fertilization was 15 kg ha^{-1} of N, 60 kg ha^{-1} of P2O5 and 60 kg ha^{-1} of K2O. The uniformity trials were carried out with cultural practices performed homogeneously throughout the experimental area, as suggested by Storck et al. (2016).

In each sowing date, an area of 48 × 24 m (1,152 m^2) was demarcated in the central part of the uniformity trial. The area of each sowing date was divided into 4,608 BEU of 0.5 ×0.5 m (0.25 m^2), forming a matrix with 96 rows and 48 columns. In the first sowing date at 110 days after sowing (DAS) and in the second sowing time at 97 DAS, the plants were cut close to the ground and the fresh matter was weighed, in grams, in each BEU when the crop was at the flowering stage.

In each sowing date with the data of fresh matter of 4,608 BEU, 64 plans of BEU with sizes X = XR×XC (X = 0.25, 0.50, 0.75, 1, 1.5, 2, 2.25, 3, 4, 4.5, 6, 8, 9, 12, 16, 18, 24, 32, 36, 48, and 64m^2) were formed (Tables 1 and 2). The abbreviations XR, XC and X stand for respectively, the number of BEU adjacent to the row, number of BEU adjacent to the column, and BEU size, in number of BEU or in square meters. Thus, the 64 BEU plans were formed between 0.5 × 0.5 m (1BEU = 0.25 m^2) and 16 ×16 m (256BEU = 64 m^2) and the fresh matter values of X_R BEU

Table 1. Plans of basic experimental units (BEU) with sizes of X = $X_R \times X_C$ in BEU and in m^2 and their respective estimates of first order spatial autocorrelation coefficient (ρ), standard deviation (s), mean (m), coefficient of variation of the trial (CV, in %), optimum plot size (Xo, in BEU), and optimum plot size (Xo, in m^2) for fresh matter of sunn hemp (*C. juncea* L.), in g 0.25 m^{-2} evaluated at 110 days after sowing (DAS) (sowing date 1) in uniformity trial with 4,608 BEU of 0.5 × 0.5 m (0.25 m^2).

Plan	X_R	X_C	X (BEU)	X (m^2)	n	ρ	s	m	CV (%)	Xo (BEU)	Xo (m^2)
1	1	1	1	0.25	4,608	0.08	563.98	1,078.28	52.30	8.16	2.04
2	1	2	2	0.5	2,304	0.16	838.63	2,156.55	38.89	6.65	3.33
3	1	3	3	0.75	1,536	0.22	1,070.26	3,234.83	33.09	5.93	4.45
4	1	4	4	1	1,152	0.26	1,294.33	4,313.11	30.01	5.51	5.51
5	1	6	6	1.5	768	0.32	1,700.47	6,469.66	26.28	4.99	7.48
6	1	8	8	2	576	0.34	2,080.39	8,626.22	24.12	4.68	9.37
7	1	12	12	3	384	0.28	2,846.89	12,939.33	22.00	4.46	13.39
8	1	16	16	4	288	0.23	3,519.46	17,252.43	20.40	4.28	17.14
9	2	1	2	0.5	2,304	0.11	812.48	21,56.55	37.68	6.54	3.27
10	2	2	4	1	1,152	0.17	1,220.70	4,313.11	28.30	5.38	5.38
11	2	3	6	1.5	768	0.25	1,588.39	6,469.66	24.55	4.83	7.25
12	2	4	8	2	576	0.37	1,892.96	8,626.22	21.94	4.36	8.72
13	2	6	12	3	384	0.42	2,530.72	12,939.33	19.56	3.98	11.94
14	2	8	16	4	288	0.43	3,159.73	17,252.43	18.31	3.79	15.17
15	2	12	24	6	192	0.36	4,357.29	25,878.65	16.84	3.67	22.00
16	2	16	32	8	144	0.25	5,591.30	34,504.87	16.20	3.66	29.30
17	3	1	3	0.75	1,536	0.08	993.40	3,234.83	30.71	5.72	4.29
18	3	2	6	1.5	768	0.18	1,458.78	6,469.66	22.55	4.61	6.92
19	3	3	9	2.25	512	0.29	1,871.87	9,704.49	19.29	4.08	9.19
20	3	4	12	3	384	0.36	2,281.10	12,939.33	17.63	3.78	11.35
21	3	6	18	4.5	256	0.43	3,012.91	19,408.99	15.52	3.40	15.28
22	3	8	24	6	192	0.44	3,746.90	25,878.65	14.48	3.23	19.38
23	3	12	36	9	128	0.40	5,102.66	38,817.98	13.15	3.07	27.64
24	3	16	48	12	96	0.19	6,695.72	51,757.30	12.94	3.18	38.19
25	4	1	4	1	1,152	0.09	1,150.86	4,313.11	26.68	5.21	5.21
26	4	2	8	2	576	0.11	1,709.72	8,626.22	19.82	4.27	8.53
27	4	3	12	3	384	0.18	2,186.02	12,939.33	16.89	3.81	11.42
28	4	4	16	4	288	0.35	2,553.33	17,252.43	14.80	3.37	13.49
29	4	6	24	6	192	0.42	3,359.00	25,878.65	12.98	3.03	18.20
30	4	8	32	8	144	0.41	4,184.31	34,504.87	12.13	2.91	23.25
31	4	12	48	12	96	0.32	5,661.62	51,757.30	10.94	2.78	33.34
32	4	16	64	16	72	0.16	7,358.50	69,009.74	10.66	2.81	44.93
33	6	1	6	1.5	768	0.14	1,462.01	6,469.66	22.60	4.65	6.97
34	6	2	12	3	384	0.21	2,215.26	12,939.33	17.12	3.83	11.48
35	6	3	18	4.5	256	0.31	2,867.25	19,408.99	14.77	3.40	15.30
36	6	4	24	6	192	0.41	3,486.74	25,878.65	13.47	3.12	18.71
37	6	6	36	9	128	0.48	4,625.00	38,817.98	11.91	2.80	25.18
38	6	8	48	12	96	0.47	5,781.85	51,757.30	11.17	2.69	32.32
39	6	12	72	18	64	0.40	7,823.62	77,635.95	10.08	2.58	46.36
40	6	16	96	24	48	0.12	10,571.02	103,514.60	10.21	2.74	65.74
41	8	1	8	2	576	0.16	1,757.76	8,626.22	20.38	4.33	8.65
42	8	2	16	4	288	0.20	2,685.52	17,252.43	15.57	3.60	14.38
43	8	3	24	6	192	0.30	3,486.13	25,878.65	13.47	3.21	19.26
44	8	4	32	8	144	0.45	4,196.65	34,504.87	12.16	2.86	22.91
45	8	6	48	12	96	0.51	5,569.15	51,757.30	10.76	2.58	30.91
46	8	8	64	16	72	0.45	7,196.78	69,009.74	10.43	2.59	41.38

Table 1. Contd.

47	8	12	96	24	48	0.38	9,668.45	103,514.60	9.34	2.46	59.13
48	8	16	128	32	36	0.11	13,027.99	138,019.47	9.44	2.60	83.27
49	12	1	12	3	384	0.22	2,339.03	12,939.33	18.08	3.96	11.89
50	12	2	24	6	192	0.30	3,640.53	25,878.65	14.07	3.30	19.82
51	12	3	36	9	128	0.41	4,824.25	38,817.98	12.43	2.95	26.59
52	12	4	48	12	96	0.55	5,902.92	51,757.30	11.41	2.62	31.48
53	12	6	72	18	64	0.56	8,009.48	77,635.95	10.32	2.45	44.08
54	12	8	96	24	48	0.51	10,249.21	103,514.60	9.90	2.44	58.62
55	12	12	144	36	32	0.39	14,060.29	155,271.91	9.06	2.40	86.44
56	12	16	192	48	24	0.11	19,133.25	207,029.21	9.24	2.56	123.10
57	16	1	16	4	288	0.26	2,797.68	17,252.43	16.22	3.66	14.64
58	16	2	32	8	144	0.39	4,386.11	34,504.87	12.71	3.02	24.13
59	16	3	48	12	96	0.35	6,178.69	51,757.30	11.94	2.92	35.08
60	16	4	64	16	72	0.60	7,328.79	69,009.74	10.62	2.44	38.98
61	16	6	96	24	48	0.55	10,099.39	103,514.60	9.76	2.37	56.86
62	16	8	128	32	36	0.47	13,047.54	138,019.47	9.45	2.41	76.97
63	16	12	192	48	24	0.30	18,143.33	207,029.21	8.76	2.41	115.64
64	16	16	256	64	18	0.01	24,560.49	276,038.94	8.90	2.51	160.70

X_R: Adjacent BEU to the row; X_C: adjacent BEU to the column; n: number of BEU with size of X BEU (n=4,608/X).

adjacent to the row and the X_C BEU adjacent to the column were added for its composition.

For each BEU plan with the fresh matter data, the first order spatial autocorrelation coefficient (ρ), the variance (s^2), the standard deviation (s), the mean (m), and the coefficient of variation of the trial (CV=100s/m, in %) were determined. The estimate of ρ was obtained in the row sense according to the methodology of Lessman and Atkins (1963), adapted by Paranaíba et al. (2009a). Based on the method of maximum curvature of the coefficient of variation model proposed by Paranaíba et al. (2009a), the optimum plot size (Xo) in BEU was determined by $Xo = \left(10\sqrt[3]{2(1-\rho^2)s^2 m}\right)/m$. The optimum plot size (Xo) in m^2 was determined by the multiplication of Xo in BEU, with the BEU area in m^2.

Statistical analyzes were performed with the support of Microsoft Office Excel® application.

RESULTS AND DISCUSSION

Based on fresh matter of sunn hemp data, there was variability in the estimates of first order spatial autocorrelation (ρ), standard deviation (s), mean (m), coefficient of variation of the trial (CV), values of the optimum plot size Xo (BEU) and Xo (m^2) (Figure 1) among the distinct sizes of planned BEU and between the two sowing dates. In general, the first order spatial autocorrelation coefficient (ρ) oscillated between 0.01 and 0.60 at the sowing date 1 and between 0.13 and 0.52 at the sowing date 2. This variability of ρ values between 64 BEU plans with sizes $X = X_R \times X_C$ (X = 0.25, 0.50, 0.75, 1, 1.5, 2, 2.25, 3, 4, 4.5, 6, 8 9, 12, 16, 18, 24, 32, 36, 48 and 64 m^2) demonstrates a possible dependence of ρ regarding the BEU sizes (Tables 1 and 2). The values of ρ indicate whether a BEU is independent (ρ=0) or dependent (ρ=|1|) of the adjacent BEU, that is, absence of correlation or presence of positive or negative perfect autocorrelation, respectively. The Xo calculated by the math expression $Xo = \left(10\sqrt[3]{2(1-\rho^2)s^2 m}\right)/m$, Paranaíba et al. (2009a) with fixed values of variance (s^2) and mean (m) is maximum when there is independence between the adjacent BEU.

In the two sowing date evaluation of fresh matter of sunn hemp, there was a linear increase in standard deviation (s) and mean (m) with an increase of BEU sizes (X, in BEU) (Tables 1, 2 and Figure 1). The standard deviation (s) values increased in a lower proportion than the mean (m) and the values of the coefficient of variation of the trial (CV=100s/m, in %) decreased with a power model pattern. However, there was oscillation of ρ among the 64 BEU plans, being possible that the optimum plot size (Xo) was influenced by the BEU size due to the variation of standard deviation (s) and mean (m).

The coefficient of variation (CV) values ranged from 8.76 to 52.30% for the sowing date 1 and from 7.56 to 44.65% for sowing date 2 (Tables 1 and 2), decreasing with power model pattern as there was an increase of BEU sizes (X, in BEU). Lorentz et al. (2007) found similar behavior with wheat, where the coefficient of variation decreased with increasing size of planned plots. As the CV values decreased, a decrease in the same power model pattern occurred for the plot size values in BEU.

Table 2. Plans of basic experimental units (BEU) with sizes of $X = X_R \times X_C$ in BEU and in m^2 and their respective estimates of first order spatial autocorrelation coefficient (ρ), standard deviation (s), mean (m), coefficient of variation of the trial (CV, in %), optimum plot size (Xo, in BEU) and optimum plot size (Xo, in m^2) for fresh matter of sunn hemp (*C. juncea* L.), in g 0.25 m^{-2} evaluated at 97 days after sowing (DAS) (sowing date 2) in uniformity trial with 4,608 BEU of 0.5 × 0.5 m (0.25 m^2).

Plan	X_R	X_C	X (BEU)	X (m^2)	n	ρ	s	m	CV (%)	Xo (BEU)	Xo (m^2)
1	1	1	1	0.25	4,608	0.15	394.74	884.11	44.65	7.31	1.83
2	1	2	2	0.5	2,304	0.22	593.63	1,768.22	33.57	5.99	2.99
3	1	3	3	0.75	1,536	0.29	769.51	2,652.33	29.01	5.37	4.03
4	1	4	4	1	1,152	0.33	935.98	3,536.44	26.47	5.00	5.00
5	1	6	6	1.5	768	0.32	1,247.38	5,304.66	23.51	4.63	6.95
6	1	8	8	2	576	0.33	1,544.63	7,072.88	21.84	4.40	8.80
7	1	12	12	3	384	0.33	2,086.03	10,609.32	19.66	4.10	12.29
8	1	16	16	4	288	0.29	2,599.53	14,145.76	18.38	3.96	15.83
9	2	1	2	0.5	2,304	0.13	586.84	1,768.22	33.19	6.01	3.00
10	2	2	4	1	1,152	0.20	875.10	3,536.44	24.75	4.90	4.90
11	2	3	6	1.5	768	0.27	1,126.76	5,304.66	21.24	4.38	6.56
12	2	4	8	2	576	0.28	1,374.23	7,072.88	19.43	4.11	8.23
13	2	6	12	3	384	0.31	1,817.25	10,609.32	17.13	3.76	11.27
14	2	8	16	4	288	0.29	2,213.82	14,145.76	15.65	3.55	14.21
15	2	12	24	6	192	0.31	2,984.44	21,218.64	14.07	3.29	19.75
16	2	16	32	8	144	0.30	3,700.17	28,291.51	13.08	3.14	25.15
17	3	1	3	0.75	1,536	0.17	759.08	2,652.33	28.62	5.42	4.06
18	3	2	6	1.5	768	0.19	1,150.51	5,304.66	21.69	4.49	6.74
19	3	3	9	2.25	512	0.27	1,492.18	7,956.99	18.75	4.02	9.05
20	3	4	12	3	384	0.29	1,810.00	10,609.32	17.06	3.76	11.28
21	3	6	18	4.5	256	0.29	2,406.52	15,913.98	15.12	3.47	15.64
22	3	8	24	6	192	0.33	2,924.16	21,218.64	13.78	3.23	19.39
23	3	12	36	9	128	0.38	3,997.96	31,827.95	12.56	3.00	27.01
24	3	16	48	12	96	0.40	4,953.57	42,437.27	11.67	2.84	34.10
25	4	1	4	1	1,152	0.15	870.34	3,536.44	24.61	4.91	4.91
26	4	2	8	2	576	0.15	1,285.78	7,072.88	18.18	4.01	8.02
27	4	3	12	3	384	0.23	1,642.98	10,609.32	15.49	3.57	10.70
28	4	4	16	4	288	0.27	1,979.54	14,145.76	13.99	3.31	13.24
29	4	6	24	6	192	0.31	2,607.00	21,218.64	12.29	3.01	18.05
30	4	8	32	8	144	0.45	3,062.59	28,291.51	10.83	2.66	21.26
31	4	12	48	12	96	0.40	4,266.97	42,437.27	10.05	2.57	30.86
32	4	16	64	16	72	0.44	5,245.03	56,583.03	9.27	2.40	38.46
33	6	1	6	1.5	768	0.19	1,160.61	5,304.66	21.88	4.52	6.78
34	6	2	12	3	384	0.18	1,757.91	10,609.32	16.57	3.76	11.28
35	6	3	18	4.5	256	0.30	2,239.05	15,913.98	14.07	3.30	14.85
36	6	4	24	6	192	0.28	2,755.40	21,218.64	12.99	3.15	18.88
37	6	6	36	9	128	0.35	3,592.20	31,827.95	11.29	2.82	25.37
38	6	8	48	12	96	0.45	4,313.68	42,437.27	10.16	2.54	30.50
39	6	12	72	18	64	0.41	5,948.10	63,655.91	9.34	2.44	43.97
40	6	16	96	24	48	0.49	7,316.55	84,874.54	8.62	2.25	53.92
41	8	1	8	2	576	0.22	1,421.07	7,072.88	20.09	4.25	8.51
42	8	2	16	4	288	0.18	2,120.38	14,145.76	14.99	3.51	14.06
43	8	3	24	6	192	0.27	2,749.93	21,218.64	12.96	3.15	18.89
44	8	4	32	8	144	0.27	3,357.60	28,291.51	11.87	2.97	23.74
45	8	6	48	12	96	0.35	4,351.73	42,437.27	10.25	2.64	31.72
46	8	8	64	16	72	0.48	5,197.48	56,583.03	9.19	2.35	37.65

Table 2. Contd.

47	8	12	96	24	48	0.43	7,196.32	84,874.54	8.48	2.27	54.56
48	8	16	128	32	36	0.46	8,959.49	113,166.06	7.92	2.15	68.68
49	12	1	12	3	384	0.27	1,907.57	10,609.32	17.98	3.91	11.74
50	12	2	24	6	192	0.23	2,923.34	21,218.64	13.78	3.30	19.82
51	12	3	36	9	128	0.38	3,754.72	31,827.95	11.80	2.88	25.88
52	12	4	48	12	96	0.28	4,787.48	42,437.27	11.28	2.86	34.33
53	12	6	72	18	64	0.36	6,196.34	63,655.91	9.73	2.54	45.77
54	12	8	96	24	48	0.51	7,436.41	84,874.54	8.76	2.25	53.97
55	12	12	144	36	32	0.45	10,270.23	127,311.81	8.07	2.18	78.65
56	12	16	192	48	24	0.49	12,840.42	169,749.08	7.56	2.06	98.66
57	16	1	16	4	288	0.30	2,441.42	14,145.76	17.26	3.79	15.15
58	16	2	32	8	144	0.28	3,757.95	28,291.51	13.28	3.19	25.56
59	16	3	48	12	96	0.39	4,939.36	42,437.27	11.64	2.85	34.14
60	16	4	64	16	72	0.31	6,293.07	56,583.03	11.12	2.82	45.06
61	16	6	96	24	48	0.38	8,277.47	84,874.54	9.75	2.53	60.75
62	16	8	128	32	36	0.52	9,980.21	113,166.06	8.82	2.25	72.05
63	16	12	192	48	24	0.47	13,943.53	169,749.08	8.21	2.19	105.10
64	16	16	256	64	18	0.48	17,523.77	226,332.11	7.74	2.10	134.21

X_R: adjacent BEU to the row; X_C: adjacent BEU to the column; n: number of BEU with size of X BEU (n=4,608/X).

In larger plots due to the increase of BEU sizes (X, in BEU), decrease of coefficient of variation (CV) values occurred and consequently improvements in the experimental inferences. Whereas with small increments in BEU size (X, in BEU), significant gains in precision occurs, that is, reduction of CV and a tendency to stabilize these gains with the increase in the BEU dimensions (Figure 1). In potato, the Xo obtained in uniformity trials is more influenced by the coefficient of variation value among the plots of one BEU than by the yield heterogeneity index (Oliveira et al., 2006).

With the increase of BEU sizes (X, in BEU), there was a reduction of the optimum plot size (Xo, in BEU) with power model pattern (Figure 1) oscillating between 8.16 and 2.37BEU for sowing date 1 and between 7.31 and 2.06 BEU for sowing date 2 (Tables 1 and 2). However, the optimum plot size (Xo, in m^2) increased linearly with the increase of BEU sizes (X, in BEU) (Figure 1) oscillating between 5.30 and 18.24 m^2 for sowing date 1 and between 16.34 m^2 and 4.60 for sowing date 2 (Tables 1 and 2).

Thus, it can be inferred that the optimum plot size for the evaluation of fresh matter of sunn hemp depends on the BEU size, in agreement with the study performed by Oliveira et al. (2005). These authors verified the effect of BEU size (1, 2, 3, 4, 6, 8, and 12 planting holes) on the optimum plot size estimated by the method of the modified maximum curvature (Meier and Lessman, 1971). For white lupine (*Lupinus albus* L.), fresh matter was evaluated in three sowing dates in 432BEU of 1 m^2 for each sowing date, with the formation of 16 plans with BEU sizes ranging from 1 to 16 m^2. In this way, the authors concluded that the estimate of the optimum plot size depends on the BEU size and indicated the evaluation of fresh matter in BEU size as small as possible to be used in the estimation of the optimum plot size (Cargnelutti Filho et al., 2016a).

In forage turnip, in order to verify the influence of BEU size on the estimate of the optimum plot size for fresh matter based on 3,456 BEU of 0.5 × 0.5 m, by the method of the maximum curvature of the coefficient of variation model, Cargnelutti Filho et al. (2016b) stated that the optimum plot size depends on the BEU size and the evaluation of fresh matter should be performed in basic experimental units as small as possible.

In these studies, the authors concluded that the BEU size affects the estimate of the optimum plot size. Thus, it can be concluded that the BEU size should be as small as possible for not overestimating the optimum plot size, as the optimum plot size is influenced by the uniformity trial size (Storck et al., 2006b). However, the uniformity trial size of potato measured in number of planting holes does not affect the estimate of the optimum plot size (Storck et al., 2006b).

Both the BEU size as the variation between plots and the experimental area heterogeneity are determining factors in estimating the optimum plot size by the method of Paranaíba et al. (2009a). The method is dependent on the BEU size and the variability existing among BEU. Therefore, it is important to consider these factors

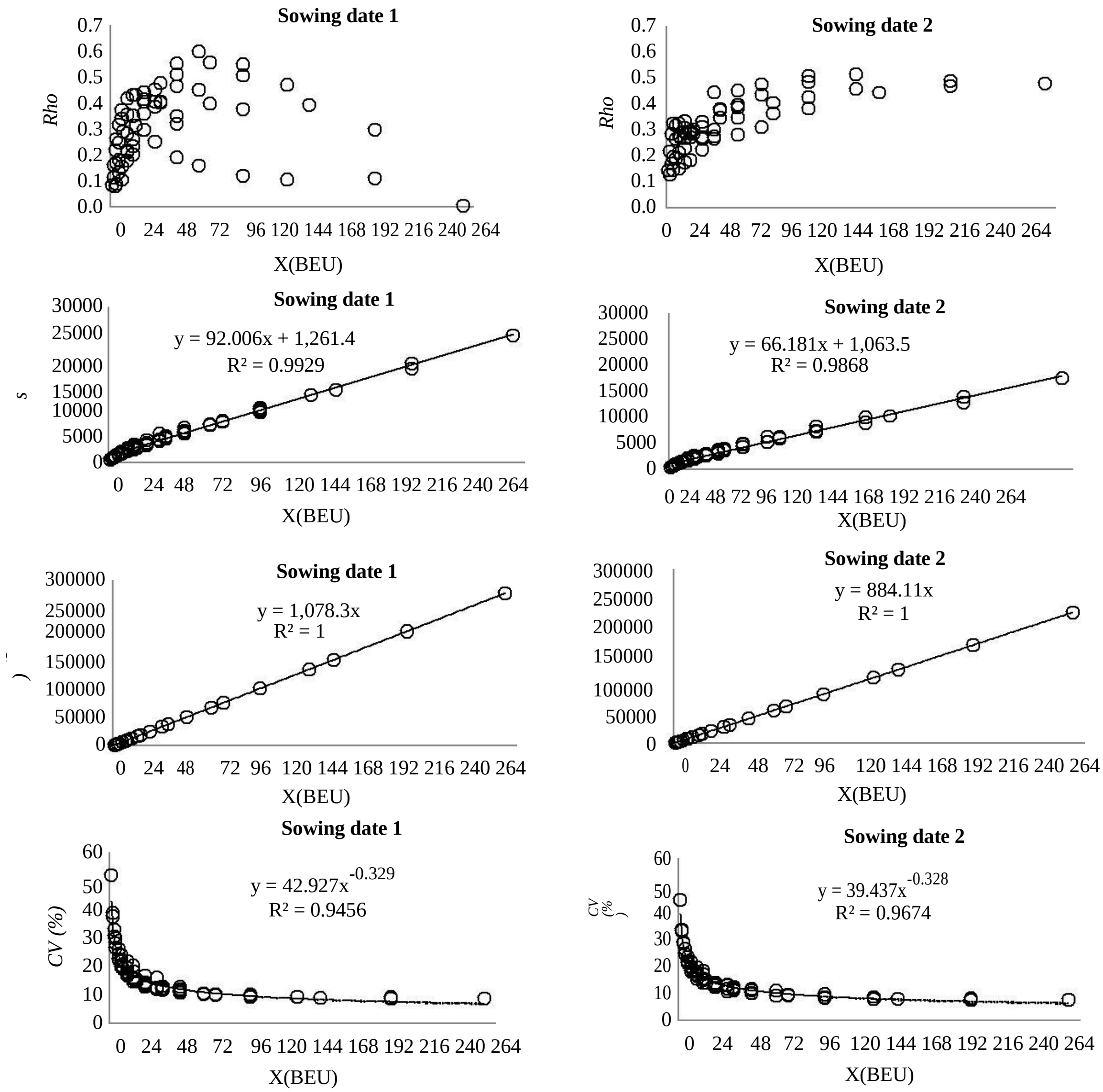

Figure 1. Relations between the dependent variables first order spatial autocorrelation coefficient (ρ), standard deviation (s), mean (m), coefficient of variation of the trial (CV, in %), optimum plot size (Xo, in BEU) and optimum plot size (Xo, in m^2) with the independent variable BEU size (X, in BEU) for fresh matter of sunn hemp (*Crotalaria juncea* L.) in g 0.25 m^{-2} evaluated in the first (Sowing date 1) and second (Sowing date 2) sowing date.

together, besides the possible limitations of the experimental area, financial costs for evaluations, and the definition of the plot size in X BEU for planning experiments with sunn hemp.

Conclusions

The estimate of the optimum plot size for the evaluation of fresh matter of sunn hemp (*C. juncea* L.) estimated by the method of maximum curvature of the coefficient of variation model depends on the size of the basic experimental unit. Determining the plot size to assess the fresh matter in basic experimental units as small as possible is recommended in order to prevent overestimation of the plot size and to contemplate all existing variability.

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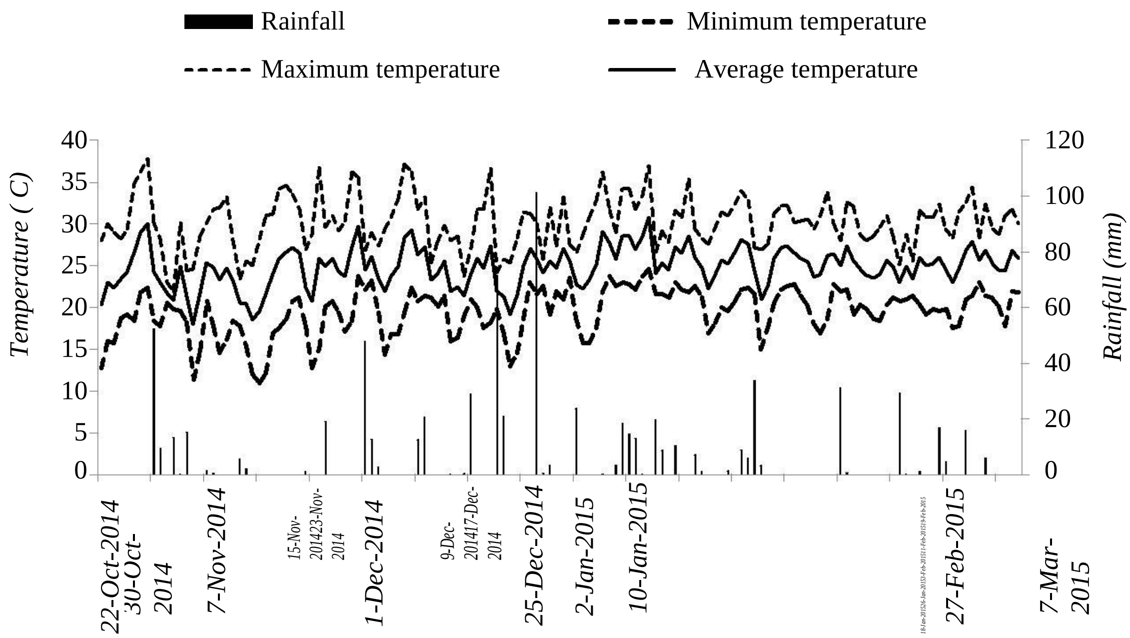

Figure 2. Minimum, maximum and mean daily air temperatures (°C) and rainfall (mm).

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Conflict of interests

The authors have not declared any conflict of interest.

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