Revista Ciência Agronômica, v. 49, n. 4, p. 663-672, out-dez, 2018
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Scientific Article
ISSN 1806-6690

Organic residue with high potassium content on sunflower cultivars[1]

Resíduo orgânico de alto teor de potássio sobre cultivares de girassol

Maria da Conceição Freitas Moura[2]*, Alek Sandro Dutra[3], Darlene Maia Grangeiro[2] and Wesley do Nascimento Sousa[2]

ABSTRACT - The use of organic sources that include levels of potassium, in addition to having an influence on the achenes and on plant development, reduces production costs and has less impact on the environment. The aim of this study was to evaluate the efficiency of fertilisation using organic residue generated by the coffee roasting process, which has a high level of potassium, on agronomic characteristics, production components and physiological quality of the achenes. The experimental design was a 2x4+2 factorial scheme, with two cultivars, four doses of organic residue (T_1=0, T_2=40, T_3=80 and T_4=120 kg K ha^{-1}), plus a control of potassium chloride at a dose of 60 kg K ha^{-1} for each cultivar. The variables under analysis were plant height, stem diameter at ground level, capitulum diameter, number of leaves, leaf area, leaf area index, 1000-achene weight, productivity and oil content. The physiological quality of the achenes was also determined by the germination test, first germination count, seedling emergence, emergence speed index, shoot length, shoot dry weight and accelerated-ageing test. Fertilisation with organic residue is efficient for the agronomic characteristics and production components of the sunflower; doses of less than 40 kg K ha^{-1} or over 70 kg K ha^{-1} from the organic residue may have a negative effect on the physiological quality of sunflower achenes.

Key words: *Helianthus annuus* L.. Fertiliser. Productivity. Achenes.

RESUMO - A utilização de fontes orgânicas que possuem em sua constituição teores de potássio, além de exercer influência nos aquênios e desenvolvimento da planta, reduz os custos de produção e os impactos sobre o meio ambiente. Objetivou-se avaliar a eficiência da adubação com resíduo orgânico gerado do processo da torrefação do grão do café, que possui elevado índice de potássio sobre as características agronômicas, componentes de produção e a qualidade fisiológica dos aquênios. O delineamento empregado foi em esquema fatorial 2x4+2, em que dois são os cultivares, quatro as doses do resíduo orgânico (T_1=0, T_2=40, T_3=80 e T_4=120 kg de K ha^{-1}), mais a testemunha adicional que foi o cloreto de potássio na dosagem de 60 kg ha^{-1} de K para ambos as cultivares. As variáveis analisadas foram: altura da planta, diâmetro do caule ao nível do solo, diâmetro do capítulo, número de folhas, área foliar, índice de área foliar, massa de 1000 aquênios, produtividade, teor de óleo e a qualidade fisiológica dos aquênios, determinados por meio do teste de germinação, primeira contagem de germinação, emergência de plântulas, índice de velocidade de emergência, comprimento da parte aérea, massa seca da parte aérea e o teste de envelhecimento acelerado. A adubação com o resíduo orgânico é eficiente sobre as características agronômicas e os componentes de produção do girassol, sendo que as doses inferiores a 40 kg ha^{-1} e doses acima de 70 kg ha^{-1} de K do resíduo orgânico podem proporcionar efeito negativo sobre a qualidade fisiológica dos aquênios de girassol.

Palavras-chaves: *Helianthus annuus* L.. Adubo. Produtividade. Aquênios.

DOI: 10.5935/1806-6690.20180075
*Author for correspondence
Received for publication on 30/09/2017; approved on 18/01/2018
[1]Parte da Tese de Doutorado da primeira autora apresentada na Universidade Federal do Ceará/UFC
[2]Universidade Federal do Ceará/UFC, Fortaleza-CE, Brasil, ceicaomoura@hotmail.com, darlenemg85@hotmail.com, sds.wesley@hotmail.com
[3]Departamento de Fitotecnia, Universidade Federal do Ceará/UFC, Fortaleza-CE, Brasil, alekdutra@ufc.br

INTRODUCTION

The use of agro-industrial residue as a source of organic fertiliser has shown promising results in agricultural crops. One alternative organic source that can be used as fertiliser is the by-product generated by the coffee roasting industry, which, by means of chemical analysis, has been shown to have high mineral levels, especially of potassium, an essential nutrient for achene production and plant development.

The use of agro-industrial residue in agriculture reduces production costs and, as this is an environmentally correct use of such residue, has less impact on the environment. Organic fertilisers used on the soil, in addition to improving fertility and increasing cation exchange capacity and nutrient release, give improvements in such physical conditions of the soil as particle aggregation, structuring and stability, in addition to improving the water retention capacity and favouring microbiological fauna (DANTAS *et al*., 2013).

Potassium is the nutrient which is most required by sunflower plants, where its availability should be from medium to high (SILVA *et al*., 2014). Castro *et al*. (2006) consider the sunflower a plant that accumulates potassium.

The aim of the present research therefore, was to evaluate the efficiency of fertilisation using organic residue generated by the coffee roasting process, which has a high level of potassium, on the agronomic characteristics, the production components and the physiological quality of the achenes.

MATERIAL AND METHODS

The experiment was carried out in two cycles (July to November of 2014 and April to August of 2015), in the experimental area of the Agricultural Sector of the Seed Analysis Laboratory, which is in the Department of Plant Science of the Centre for Agrarian Sciences of the Universidade Federal do Ceará (UFC), located on the Campus do Pici in Fortaleza, in the State of Ceará, Brazil.

Prior to setting up the experiment for each cycle, soil samples were collected in the 0-20 and 20-40 cm layers; the chemical characteristics of the soil are shown in Table 1. Twenty random points were sampled in the area, with the sub-samples being mixed to obtain a composite soil sample.

The residue to be used as treatment was obtained after the process of roasting coffee at 270 °C (Table 2). Before being used, the residue was left for one week, arranged on benches in a greenhouse, at a temperature of from 28 to 30 ºC to dry completely. The residue was then stored in plastic bags, sealed to avoid contamination, and later used as fertiliser.

To prepare the experimental area, the soil was ploughed, and then cross-harrowed twice. Sowing was carried out using sunflower seeds of the BRS 122 and BRS 323 cultivars. Fertilisation was based on the soil analysis, using urea as the source of nitrogen at a dose of 60 kg N ha^{-1}, divided into two applications: the first as base fertiliser when planting, and the second as dressing 35 days after planting, together with boric acid at an a rate of 2 kg B ha^{-1}. The source of phosphorus was single superphosphate at a dose of 80 kg P_2O_5 ha^{-1}, applied only once when planting.

Sowing was in single rows, at a spacing of 0.7 m between rows x 0.3 m between plants. There were four replications for each treatment, corresponding to four blocks. The experimental design was a 2x4 + 2 factorial scheme, with two cultivars, four doses of organic residue (T_1=0, T_2=40, T_3=80 and T_4=120 kg K ha^{-1}), plus a control of potassium chloride at a dose of 60 kg K ha^{-1} for each cultivar.

The following variables were analysed for each crop cycle: plant height; stem diameter at ground level; capitulum diameter; number of leaves; leaf area, as per the methodology described by Ashley, Doss and Bennett (1963); and the leaf area index (LAI), determined by dividing the leaf area by the area of plant spacing. Plant height, stem diameter at ground level, number of leaves and leaf area were collected at 30, 45, 60, 75 and 90 days after sowing (DAS).

The following were also determined at the end of each crop cycle: the 1000-achene weight, by counting and weighing on a scale to two decimal places eight samples of 100 achenes taken from the working area of each plot; achene production (from the total weight of achenes from each working plot, extrapolated to the hectare); and the oil content (obtained by the hot solvent method (hexane) in TE-044 (TECNAL) fat determinator, using a macerated sample of 5 g per plot).

Evaluation of the physical quality of the achenes was initially determined for each crop cycle by means of the germination test, carried out on four replications of 50 achenes, on a roll of Germitest® paper moistened with distilled water at a ratio of 2.5 times the weight of the paper. Evaluation of normal seedlings was made 10 days after sowing, based on seedlings with a complete, developed and healthy structure.

Together with the germination test, the first germination count was carried out four days after the

Table 1 - Chemical and granulometric constituents of the soil collected in the 0-20 and 20-40 cm layers. Fortaleza, Ceará (2014 and 2015)

Layer (cm)	pH	P	K	Na	Mg	Al	Ca	M.O	Sand	Silt	Clay
		(mg kg^{-1})			(cmolc kg^{-1})			(g kg^{-1})		(g kg^{-1})	
0-20 (2014)	5.8	10	0.13	0.11	0.80	0.10	1.00	7.55	370	64	153
20-40	5.9	3	0.12	0.17	0.80	0.15	1.00	5.79	366	59	242
0-20 (2015)	6.8	6	0.17	0.13	0.70	0.15	1.00	7.45	416	78	72
20-40	6.7	6	0.17	0.20	0.60	0.20	0.60	5.79	508	81	95

Source: Soil and Plant Analysis Laboratory, Department of Soils, Universidade Federal do Ceará, Fortaleza, Ceará

Table 2 - Chemical constituents of the organic residue used in the treatments. Fortaleza, Ceará (2014 and 2015)

Chemical characteristics of the organic residue											
N	(g kg^{-1})									(mg kg^{-1})	
	M.O	P	P2O5	K	K2O	Ca	Mg	Fe	Cu	Zn	Mn
12.9	331.2	7.1	16.3	83.3	101.6	48.6	28.7	4632.9	216.9	71.9	219.5

Source: Soil and Plant Analysis Laboratory, Department of Soils, Universidade Federal do Ceará, Fortaleza, Ceará

normal-seedling count, with the results also expressed as a percentage (BRASIL, 2009).

To evaluate the achenes, the accelerated-ageing test was also carried out for each production cycle using plastic boxes containing 40 mL of water. These were kept in a BOD chamber at 42 °C for 48 hours. After this ageing period, samples of 50 achenes were submitted to the germination test, following the methodology described above, with evaluations made on the fourth day after sowing.

The physical quality of the achenes was also evaluated by seedling emergence for each cycle, using four samples of 50 achenes per treatment, which were sown in a bed containing sand as substrate. The speed of emergence index (SEI) was determined as per Maguire (1962). At the end of the emergence test, the length of the shoots was determined using a rule graduated in millimetres; this material was then placed in an air circulation oven at 65 ºC for 72 hours. The dry weight of the shoots was later determined from the dry weight of the material.

The data were submitted to analysis of variance and Tukey's test at 5% probability to compare mean values, using the ESTAT software (ESTAT, 1994); the effects of each dose were determined by regression analysis, using the SISVAR software (FERREIRA, 2011) with no data transformation.

RESULTS AND DISCUSSION

According to the results obtained in the two crop cycles, during the first planting cycle, the only significance was found between cultivars, with the BRS 323 cultivar being superior to BRS 122 for number of leaves at 75 days after sowing,. The latter had an average of 14 leaves per plant, while BRS 323 had on average 17 leaves (Table 3). There were no significant differences for the other evaluation periods.

Table 3 - Mean number of leaves in the sunflower cultivars during the first production cycle. Fortaleza, Ceará (2014)

Cultivar	Days after sowing		
	60	75	90
BRS 323	20 a	17 a	12 a
BRS 122	18 a	14 b	11 a

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

During the second planting cycle, significance was seen for the number of leaves, plant height, capitulum diameter, 1000-achene weight and productivity. For the number of leaves, significance was found for the cultivars for the three evaluation periods (Table 4).

According to the results, the BRS 323 cultivar had the highest mean values, i.e. the highest number of leaves for both evaluation periods. According to Boechat *et al*. (2014), the number of leaves is an important variable, since it determines the development of seedlings when planted in the field, due to their photosynthetic capacity.

When analysing the cultivars that received potassium chloride during the second crop cycle (60 kg ha^{-1}), significance was found for number of leaves at 60 DAS, particularly in the BRS 122 cultivar, with an average of 15 leaves per plant, while BRS 323 had 11 leaves on average (Table 5).

Table 4 - Mean number of leaves in the sunflower cultivars during the second production cycle. Fortaleza, Ceará (2015)

Cultivar	Days after sowing		
	60	75	90
BRS 323	16 a	14 a	11 a
BRS 122	14 b	11 b	7 b

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

Table 5 - Mean number of leaves in the sunflower cultivars fertilised with potassium chloride during the second production cycle. Fortaleza, Ceará (2015)

Cultivar	Days after sowing		
	60	75	90
BRS 122	15 a	13 a	10 a
BRS 323	11 b	13 a	10 a

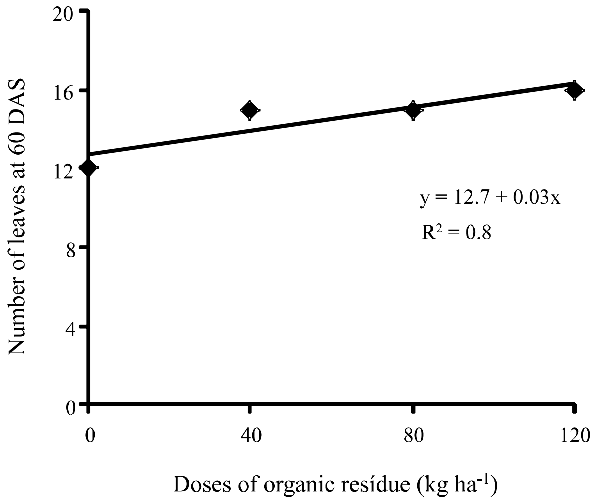
*Mean values followed by the same letter do not differ by Tukey's test at 5% probability

In studies by Campos, Chaves and Guerra (2015), using NPK fertiliser on the sunflower (BRS 122), it was found that the number of leaves in the sunflower plants was influenced by interaction of the potassium dose at 60 DAS, where the average number of leaves obtained at the estimated dose of 51 kg K_2O ha^{-1} was 23. In this study, the results obtained for number of leaves with the control treatment (60 kg ha^{-1} potassium chloride) were lower than the results found by the above authors. This characteristic can be attributed to the environmental conditions of the areas where the work was carried out.

Regarding the difference in the doses of organic residue during the second crop cycle for number of leaves (Figure 1), it can be seen that this variable adjusted to the linear regression model, with the greatest number of leaves being seen in the cultivars that received the dose of 120 kg ha^{-1}, with a total of 16 leaves. For the cultivars fertilised with doses of 40 and 80 kg ha^{-1}, it was found that they presented on average 15 leaves per plant, while for the cultivars in the treatments with no potassium fertiliser, an average of 12 leaves were seen per plant.

In the parametric analysis for plant height during the second crop cycle, significance was seen for the cultivars at 30, 45 and 60 DAS ($p<0.01$) and for the controls at 30 DAS ($p<0.05$). The responses found in this study for plant

Figure 1 - Number of leaves in sunflower plants at 60 DAS for dose of organic residue during the second production cycle. Fortaleza, Ceará (2015)



height during the second crop cycle show that the BRS 122 cultivar had the greatest plant height at 30, 45 and 60 DAS, with mean values of 21 cm, 36 cm and 63 cm respectively, while for BRS 323 during the same evaluation periods, the mean values varied around 16 cm, 26 cm and 49 cm respectively.

In the plants that received potassium chloride at 30 DAS, it was found that 'BRS 122' had a height of 21 cm, whereas for 'BRS 323', mean plant height was 17 cm. Uchôa *et al*. (2011), analysing a dressing of potassium fertiliser on the production components of the sunflower, found that plant height in the BRS 122 variety was 1.26 m. However, in the present study, using potassium chloride at a dose of 60 kg ha^{-1}, plant height was lower during the second crop cycle than that found by the above authors.

Such a result can be attributed to the period of evaluation, since the above authors obtained this average during the final stage of sunflower development, whereas the mean values for this study refer to 30 DAS. However, when analysing the final height of 'BRS 122' at 90 DAS during the first and second crop cycles, heights of 1.57 m and 66 cm were found respectively. The plants that received potassium chloride during the first planting cycle showed greater values than those found by Uchôa *et al*. (2011).

When evaluating capitulum diameter (CD) and productivity in the sunflower cultivars during the second crop cycle, significance was seen for the cultivars as well as the control (Table 6), and in the interaction between doses and cultivars relevant to the 1000-achene weight.

Table 6 - Summary of the analysis of variance for capitulum diameter (CD), productivity and 1000-achene weight in the sunflower during the second production cycle. Fortaleza, Ceará (2015)

SV	DF	CD	Prod.	1000-achene weight
		F value		
Contr. x Factors	1	0.55^{ns}	0.92^{ns}	2.48^{ns}
Control	1	2.30^{ns}	4.80*	1.93^{ns}
Cultivar	1	5.85*	5.37*	41.05**
Dose	3	0.39^{ns}	1.39^{ns}	2.37^{ns}
C x D	3	0.58^{ns}	1.33^{ns}	4.26*
Treatments	9	1.29^{ns}	2.14^{ns}	7.26**
Block	3	0.02^{ns}	14.11^{ns}	-
CV(%)		25.70	56.72	10.49

^{ns}, * and **- Not significant and significant at 1% e 5%. SV= source of variation, DF= dgrees of freedom, CV= coefficient of variation

The greatest value for capitulum diameter was seen in the BRS 323 cultivar, with a diameter of around 90 mm (Table 7), when compared to BRS 122, where the diameter was 72.54 mm. According to Silva *et al*. (2009), there is a direct influence from capitulum diameter on the potential number of achenes produced, as well as on the 1000-achene weight (PIVETTA *et al*., 2012) and consequently on productivity. This is also confirmed by Amorin *et al*. (2008), who found a significant correlation of achene production with capitulum diameter.

Table 7 - Capitulum diameter and productivity in sunflower cultivars during the second planting cycle. Fortaleza, Ceará. (2015)

Cultivar	Production components	
	CD (mm)	PROD (kg ha^{-1})
BRS 323	90.15 a	793.07 a
BRS 122	72.54 b	504.20 b

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

When analysing the response of the cultivars relative to productivity, it was seen that the BRS 323 cultivar obtained the highest averages in kg ha^{-1} (Table 5). The results showed that the difference between the BRS 323 and BRS 122 cultivars was 288.80 kg ha^{-1}, i.e. BRS 323 showed a 36% increase in productivity in relation to BRS 122.

During the first production cycle, the mean values for productivity were higher than those found during the second crop cycle, with a variation of 2073.00 kg ha^{-1} for the BRS 323 cultivar and 1276.00 kg ha^{-1} for BRS 122. The negative attributes that influenced the reduction in productivity for the second crop cycle are related to weed interference during the critical time of crop development, as well as an attack on the plants by ants during the second production cycle, affecting not only productivity but also the other variables under analysis.

In the treatment with inorganic potassium, the BRS 323 cultivar stood out, with a mean value of 787.80 kg ha^{-1}, while the BRS 122 cultivar obtained an average of 241.60 kg ha^{-1}. The mean values obtained during the second crop cycle were lower than seen during the first cycle, when BRS 323 had a productivity of 2395.00 kg ha^{-1} and BRS 122 a mean value of 1838.00 kg ha^{-1} (Table 8).

In studies by Uchôa *et al*. (2011), which evaluated potassium fertiliser as dressing on the production components of sunflower cultivars, it was found that with an increase in potassium fertiliser there were positive increases in the vegetative and production variables of the sunflower.

Feitosa *et al*. (2013), analysing the influence of boron and potassium fertiliser on the sunflower crop, found greater productivity at doses of 6 kg boron ha^{-1} and 90 kg potassium ha^{-1}. The increase in agricultural productivity

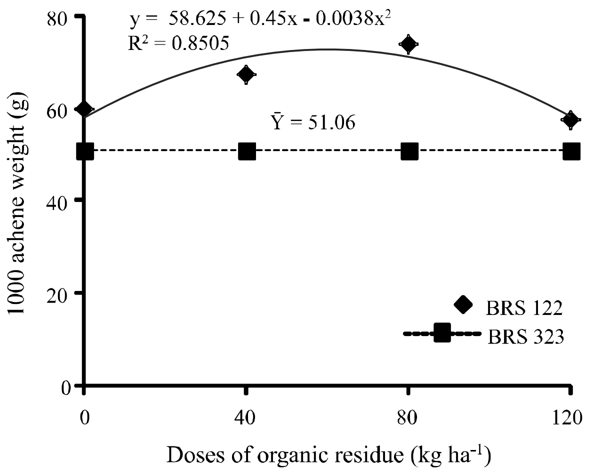
Table 8 - Productivity in sunflower cultivars fertilised with KCl during the first and second production cycles. Fortaleza, Ceará (2014 and 201)

Cultivar	Cycle 1 (kg ha^{-1})	Cycle 2 (kg ha^{-1})
BRS 323	2395.00 a	787.80 a
BRS 122	1838.00 b	241.60 b

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability from the addition of potassium fertilisers to the soil varies mainly with the amount of available potassium and with the general level of soil fertility (UCHÔA *et al*., 2011).

The significant interaction between the cultivars and the doses of organic residue relevant to the 1000-achene weight during the second cycle showed that the BRS 122 cultivar displayed differences for the dose of organic residue used, and adjusted to a quadratic polynomial regression (Figure 2). It was found that between the doses of 40 and 80 kg ha^{-1} the results increased when compared to the other doses used with the BRS 122 cultivar, and that the maximum value to promote an increase in the 1000-achene weight was the dose of 59.21 kg ha^{-1}, giving a maximum weight of 71.95 g, whereas the BRS 323 cultivar did not adjust to any mathematical regression model.

Figure 2 - Doses of organic residue on 1000-achene weight during the second production cycle



In relation to the significant difference between cultivars relative to 1000-achene weight, it can be seen in Table 9 that both differed significantly at doses of 40 and 80 kg ha^{-1}, the BRS 122 cultivar standing out with the greatest 1000-achene weight.

Table 9 - 1000-achene weight as a function of organic-residue dose during the second production cycle. Fortaleza, Ceará (2015)

Cultivar	Dose (kg ha^{-1})			
	0	40	80	120
BRS 122	59.75 a	67.25 a	74.00 a	57.50 a
BRS 323	50.50 a	49.50 b	50.50 b	53.75 a

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

Considering that achene weight is the result of the plant's ability to supply nutrients up to the potential limit established for each cultivar (BISCARO *et al*., 2008), it can be seen that the gradual release of nutrients during the crop cycle accentuates increases in the 1000-achene weight (SANTOS; WANDERLEY; SOUSA JÚNIOR, 2013).

When analysing the physiological quality of the achenes obtained during the first production cycle, significant difference was seen for first germination count (FGC), as well as for seedling emergence (SE), speed of emergence index (SEI), shoot length (SL) and shoot dry weight (SDW) (Table 10). In the physiological analysis of the achenes from the second production cycle, it was found that only shoot length showed significant differences.

From the data for first germination count, it was found that achenes of plants fertilised with the control dose (60 kg ha^{-1}) of K and the 0 kg ha^{-1} dose of K_2O differed for the BRS 122 cultivar, the control having a higher percentage (96%), while the dose with no fertiliser achieved a percentage of 84%. Snyder and Ashlock (1996) state that K deficiency may impair the physiological quality of the seeds.

Results found by Toledo *et al*. (2011) for doses of potassium in soybean and wheat, demonstrated that the best results for the physiological quality of soybean seed were obtained at the highest doses of K_2O (50 and 100 kg ha^{-1}). In the study carried out by the above authors, it can be seen that for first germination count, the doses of 50 and 100 kg K_2O ha^{-1} promoted 86% and 87% germination respectively, whereas in the soybean seedlings, 95% germination was seen in the germination test.

From the results for seedling emergence, it can be seen that the achenes from plants fertilised with twice the recommended dose (120 kg K ha^{-1}) of organic residue had a lower percentage emergence (80%) when compared to the treatment with potassium chloride for the BRS 122 cultivar, which obtained an average of 98% of emerged seedlings.

The significant difference seen in the BRS 122 cultivar in relation to the control, for both seedling emergence and first germination count, can be explained by the interference of the recommended doses on the physiology of the achenes, as well as by the cultivars, considering that for the BRS 323 cultivar there were no significant differences between the doses of organic residue and of potassium chloride. According to Marcos Filho (2005), potassium is the nutrient found in greater quantities in seeds, and is considered important for protein metabolism and enzyme activity.

Table 10 - Summary of the analysis of variance for first germination count (FGC), seedling emergence (SE), speed of emergence index (SEI), shoot length (SL) and shoot dry weight (SDW) during the first production cycle

SV	DF	FGC	SE	SEI	SL	SDW
		Square root				
Contr. x Factors	1	4.59*	5.32*	13.87**	0.07^{ns}	2.13^{ns}
Control	1	0.02^{ns}	0.36^{ns}	0.44^{ns}	5.81*	0.45^{ns}
Cultivar	1	1.11^{ns}	0.59^{ns}	0.29^{ns}	0.87^{ns}	11.37**
Dose	3	1.37^{ns}	2.43^{ns}	4.53**	7.02**	1.81^{ns}
C x D	3	0.53^{ns}	0.04^{ns}	1.41^{ns}	5.21**	0.05^{ns}
Treatment	9	1.27^{ns}	1.52^{ns}	3.60**	4.83^{ns}	2.17^{ns}
CV (%)		10.16	12.00	13.12	8.49	24.51

^{ns}, * and **- Not significant and significant at 1% e 5% respectively by F-test. SV= source of variation, DF= dgrees of freedom, CV= coefficient of variation

The results for the speed of emergence index showed significant differences for the treatments in relation to the control, where the doses of 0 and 40 kg K_2O ha^{-1} in the BRS 122 cultivar, and the doses of 0 and 120 kg K_2O ha^{-1} in the BRS cultivar 323 showed lower results than the control, i.e. the achenes from plants fertilised with potassium chloride had a better speed of emergence.

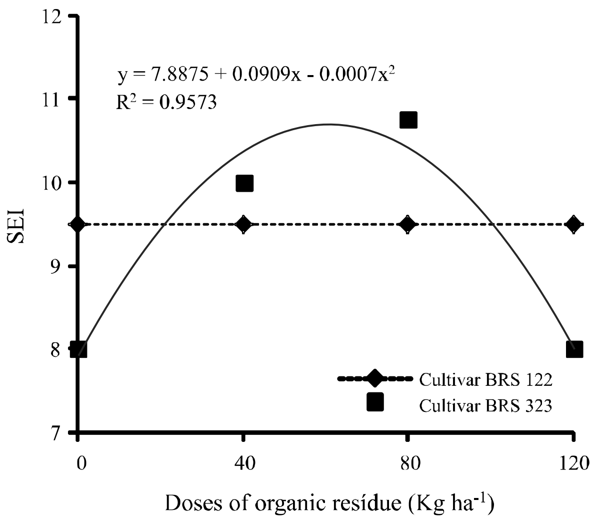
According to Mascarenhas *et al*. (1988), seed vigour is positively affected by potassium; this information is confirmed by Petter *et al*. (2014), who found that the quality of soybean seeds was influenced by the dose of potassium, obtaining the best results at a dose of 80 to 95 kg K_2O ha^{-1}.

Analysing the doses of organic residue on the SEI, it can be seen that the BRS 323 cultivar adjusted mathematically to a quadratic polynomial regression (Figure 3), with the dose of 64.93 kg K_2O ha^{-1} promoting the maximum value of 10.84 in the SEI. For the BRS 122 cultivar, there was no adjustment to any mathematical model.

The response to the behaviour seen in the BRS 323 cultivar at the dose of 120 kg ha^{-1} may be related to the amount being higher than the recommended dose for the crop: probably for this reason the SEI showed a lower value. In other words, the expression of this dose had negative repercussions on the physiological quality of the achenes. Similarly, it can be seen that for the dose of fertiliser with no source of potassium, the seedlings had a lower speed of emergence.

According to Dan *et al*. (2010), speed of emergence is an important factor in the rapid establishment of seedlings in the field, since seedlings with a higher SEI show better performance and a greater capacity to withstand the stresses that may interfere with plant growth and development.

Figure 3 - Speed of emergence index in sunflower cultivars submitted to different doses of organic residue during the first production cycle. Fortaleza, Ceará (2014)



For shoot length, a significant interaction of the doses with the cultivars was seen during both production cycles, however this variable did not adjust to any mathematical regression model (Figures 4a and 4b), and therefore the mean values for the variable were calculated.

For the cultivars, it was found that during both the first and second crop cycles, seedling length was greater in the BRS 122 cultivar compared to BRS 323 at doses of 0 and 80 kg K ha^{-1} (Table 11). This result is considered from the point of view that when analysing plant growth, it is possible to describe the morphophysiological conditions for different time intervals, thereby evaluating final plant growth as a whole, including the contribution of the different organs (BENINCASA, 2003).

Analysing differences in the seedlings from the treatment fertilised with potassium chloride (control) during both production cycles, the results showed that the greatest lengths were seen in the BRS 122 cultivar, with mean values ranging from 6.34 to 7.28 cm (Table 12). Shoot length is of great importance, as it is directly connected to the diameter, reflecting in the manner of growth and to differentiate the plant, thereby favouring the whole process related to the soil-plant system.

There were no significant differences between treatments for shoot dry weight, i.e. the doses of organic residue showed similar behaviour to the control (seedlings from the treatment with potassium chloride). However, when analysing the cultivars, significant differences were seen between them, the BRS 323 cultivar standing out with a mean value of approximately 0.87 g, while the BRS cultivar 122 had an average weight of around 0.65 g.

The seedlings of the BRS 323 cultivar showed a greater accumulation of shoot dry weight, i.e. the achenes acquired a greater accumulation of reserves during the formation process. Consequently, this had repercussions on the physiological potential of the seedlings. The production of shoot dry weight gives greater chances of survival and later seedling growth in the field, since the leaves comprise one of the principal sources of nutrients and photoassimilates (DUTRA *et al*., 2015).

Figure 4 - Mean values for shoot length (SL) in the cultivars for different doses of organic residue; first production cycle (a) and second production cycle (b). Fortaleza, Ceará (2014 and 2015)

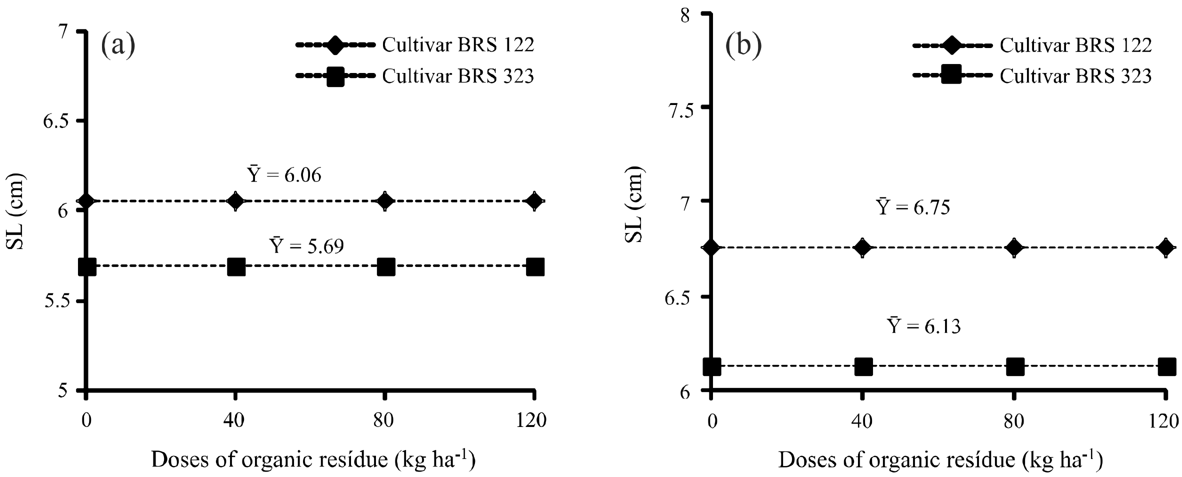


Table 11 - Differences in shoot length in the sunflower seedlings for doses of organic residue. Fortaleza, Ceará (2014 and 2015)

Cultivar	Cycle 1/ kg dose ha^{-1}			
	0	40	80	120
BRS 122	6.0 a	6.25 a	6.25 a	5.75 a
BRS 323	5.0 a	6.75 a	4.75 b	6.25 a
	Cycle 2/ kg dose ha^{-1}			
BRS 122	7.0 a	7.25 a	6.75 a	6.0 a
BRS 323	5.25 b	6.75 a	5.75 b	6.75 a

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

Table 12 - Shoot length in sunflower seedlings fertilised with potassium chloride during the two production cycles. Fortaleza, Ceará (2014 and 2015)

Cultivar	Cycle 1/ kg dose ha^{-1}			
	0	40	80	120
BRS 122	6.0 a	6.25 a	6.25 a	5.75 a
BRS 323	5.0 a	6.75 a	4.75 b	6.25 a
	Cycle 2/ kg dose ha^{-1}			
BRS 122	7.0 a	7.25 a	6.75 a	6.0 a
BRS 323	5.25 b	6.75 a	5.75 b	6.75 a

*Mean values followed by the same letter in a column do not differ by Tukey's test at 5% probability

CONCLUSIONS

1. Organic residue is efficient for the agronomic characteristics and production components of the sunflower, and can be used as an alternative source of potassium;
2. Doses of organic residue of less than 40 kg K ha^{-1} and more than 70 kg K ha^{-1} may have a negative effect on the physiological quality of sunflower achenes.

REFERENCES

AMORIN, E. P. *et al*. Correlações e análise de trilha em girassol. **Bragantia**, v. 67, n. 2, p. 307-316, 2008.

ASHLEY, D. A.; DOSS, B. D.; BENNETT, O. L. A method of determining leaf area in cotton. **Agronomy Journal**, v. 55, p. 584-585, 1963.

BENINCASA, M. M. P. **Análise de crescimento de plantas**. 2. ed. Jaboticabal: FUNEP, 2003. 41 p.

BISCARO, G. A. *et al*. Adubação nitrogenada em cobertura no girassol irrigado nas condições de Cassilândia-MS. **Ciência Agrotécnica**, v. 32, n. 5, p. 1366-1373, 2008.

BOECHAT, C. L. *et al*. Lodos de esgoto doméstico e industrial no crescimento inicial e qualidade de mudas de pinhão-manso. **Bioscience Journal**, v. 30, n. 3, p. 782-791, 2014.

BRASIL. Ministério da Agricultura e Reforma Agrária. **Regras para análise de sementes**. Brasília: SNDA: DNDV: CLAV, 2009. 365 p.

CAMPOS, V. B.; CHAVES, L. H. G.; GUERRA, H. O. C. Adubação com NPK e irrigação do girassol em Luvissolo: comportamento vegetativo. **Revista Ambiente & Água**, v. 10, n. 1, 2015.

CASTRO, C. *et al*. Rochas brasileiras como fonte alternativa de potássio para a cultura do girassol. **Espaço & Geografia**, v. 9, n. 2, p. 179-193, 2006.

DAN, L. G. M. *et al*. Qualidade fisiológica de sementes de soja tratadas com inseticidas sob efeito do armazenamento. **Revista Brasileira de Sementes**, v. 32, n. 2 p. 131-139, 2010.

DANTAS, T. A. G. *et al*. Produção do inhame em solo adubado com fontes e doses de matéria orgânica. **Revista Brasileira de Engenheira Agrícola e Ambiental**, v. 17, n. 10, p. 1061-1065, 2013.

DUTRA, T. R. *et al*. Crescimento inicial e qualidade de mudas de caviúna-do-cerrado e caroba-do-campo em resposta à adubação nitrogenada. **Agropecuária Científica no Semiárido**, v. 11, n. 3, p. 52-61, 2015.

ESTAT. **Sistema para análises estatísticas**. Versão 2.0. Jaboticabal: UNESP, 1994.

FEITOSA, H. O. *et al*. Influência da adubação borácica e potássica no desempenho do girassol. **Comunicata Scientiae**, v. 4, n. 3, p. 302-307, 2013.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v. 5, n. 6, p. 1039-1042, 2011.

MAGUIRE, J. D. Speed of germination-aid in selection and avaliation for seedling emergence and vigour. **Crop Science**, v. 2, n. 1, p. 176-177, 1962.

MARCOS FILHO, J. **Fisiologia de sementes de plantas cultivadas**. Piracicaba: FEALQ, 2005. 495 p.

MASCARENHAS, H. A. A. *et al*. Deficiência de K em soja no estado de São Paulo: melhor entendimento do problema e possíveis soluções. **O Agronômico**, v. 40, n. 1, p. 34-43, 1988.

PETTER, F. A. *et al*. Produtividade e qualidade de sementes de soja em função de doses e épocas de aplicação de potássio. **Semina: Ciências Agrárias**, v. 35, n. 1, p. 89-100, 2014.

PIVETTA, L. G. *et al*. Avaliação de híbridos de girassol e relação entre parâmetros produtivos e qualitativos. **Revista Ciência Agronômica**, v. 43, n. 3, p. 561-568, 2012.

SANTOS, J. F.; WANDERLEY, J. A. C.; SOUSA JÚNIOR, J. R. Produção de girassol submetido à adubação organomineral.

Revista Agropecuária Científica no Semiárido, v. 9, n. 3, p. 38-44, 2013.

SILVA, A. G. *et al*. Desempenho de híbridos de girassol em espaçamentos reduzidos. **Semina: Ciências Agrárias**, v. 30, n. 1, p. 31-38, 2009.

SILVA, S. S. *et al*. Crescimento do girassol com níveis de reposição hídrica e adubação potássica. **Revista Agropecuária Científica no Semiárido**, v. 10, n. 2, p. 104-110, 2014.

SNYDER, C.; ASHLOCK, L. O. Late-season potassium deficiency symptoms in Southern soybeans. **Better Crops With Plant Food**, v. 80, n. 2, p. 10-11, 1996.

TOLEDO, M. Z. *et al*. Physiological quality of soybean and wheat seeds produced with alternative potassium sources. **Revista Brasileira de Sementes**, v. 33, n. 2 p. 363-371, 2011.

UCHÔA, S. C. P. *et al*. Adubação de potássio em cobertura nos componentes de produção de cultivares de girassol. **Revista Ciência Agronômica**, v. 42, n. 1, p. 8-15, 2011.