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SOYBEAN BASE FERTILIZATION: CHEMICAL AND MICROBIOLOGICAL SOIL INDICATORS AND CROP YIELD

Paulo Henrique Cazarim, Marcelo Augusto de Aguiar e Silva, Adriana Pereira da Silva, Rodrigo Dlugosz da Silva, Gabriel Danilo Shimizu, Murilo Arruda Corsi, Eduardo Augusto Matsushima Tavares, Euler Augusto Inêz

Universidade Estadual de Londrina – UEL, Londrina, PR. E-mail: paulo_cazarim@hotmail.com

Abstract

Recent research suggests that soybean yield could be doubled in Brazilian conditions, implying that the base fertilization is pivotal, as it might influence chemical and microbiological soil indicators and, hence, the crop grain yield. The current study had the goal of assessing alterations in the chemical and microbiological soil indicators, in the short term, as well as the soybean biometric and grain yield performance as a function of different fertilizers for base fertilization, in two sowing periods. An experiment comprised of two sowing periods was carried out in the 2019/2020 season on a dystrophic Red Latosol, in north Parana state. Five treatments were assessed, comprising: 1) control; 2) mineral fertilizer; 3) organomineral fertilizer; 4) mineral fertilizer mixed with granulated gypsum; and 5) slow release mineral fertilizer. A randomized block design with four replicates was adopted. The following variables were assessed: chemical and microbiological soil indicators; final stand; first pod insertion height; plant height; stem diameter; number of pods per plant; number of grains per plant; number of grains per pod; grain mass per plant; and one thousand grain mass and grain yield. There is no base fertilization effect on the chemical soil indicators in the short term, however, there is an effect on the microbiological soil indicators. Soybean biometric and grain yield performance is decreased with the delayed sowing period, regardless of the type of fertilizer utilized for base fertilization. Analyzing a set of soil quality indicators enables precise and judicious results to be gathered on management practices in the soil environment.

Keywords: basal respiration; microbial biomass; mineral fertilizer; organomineral fertilizer; soil chemistry.

ADUBAÇÃO DE BASE NA SOJA: INDICADORES QUÍMICOS E MICROBIOLÓGICOS DO SOLO E PRODUTIVIDADE DA CULTURA

Resumo

Pesquisas recentes apontam que a produtividade da soja pode ser duplicada em condições brasileiras, para tanto, a adubação de base se mostra fundamental, pois pode interferir nos indicadores químicos e microbiológicos do solo e, consequentemente, no rendimento da cultura. Assim, objetivou-se avaliar as alterações nos indicadores químicos e microbiológicos do solo, no curto prazo, e o desempenho fitométrico e produtivo da soja em função do uso de diferentes fertilizantes na adubação de base, em duas épocas de semeadura. Foi conduzido experimento em duas épocas de semeadura na safra 2019/2020, em um Latossolo Vermelho distroférrico, no norte do estado do Paraná. Foram avaliados cinco tratamentos que consistiram de: 1) controle; 2) fertilizante mineral; 3) fertilizante organomineral; 4) fertilizante mineral em mistura com gesso granulado e 5) fertilizante mineral de liberação lenta. O delineamento experimental foi em blocos ao acaso com quatro repetições. Foram avaliados os indicadores químicos e microbiológicos do solo; estande final; altura de inserção da primeira vagem; altura de planta; diâmetro do caule; número de vagens por planta; número de grãos por planta; número de grãos por vagem; massa de grãos por planta; massa de mil grãos e produtividade. Não há efeito da adubação de base sobre os indicadores químicos do solo no curto prazo, porém, há efeito sobre os indicadores microbiológicos. O desempenho fitométrico e produtivo da soja é reduzido conforme o atraso da semeadura, independentemente do tipo de fertilizante utilizado na adubação de base. A análise conjunta de indicadores de qualidade do solo permite a obtenção de resultados precisos e criteriosos sobre as práticas de manejo no ambiente do solo.

Palavras-chave: biomassa microbiana; fertilizante organomineral; fertilizante mineral; química do solo; respiração basal.

Introduction

The soybean crop is of great importance to Brazilian agriculture, occupying an area of approximately 38.4 million hectares, with total production and grain yield estimated at 135.5 million tons and 3523 kg ha^{-1}, respectively (CONAB, 2021). National studies indicate that the average grain yield in soybean crop fields could be doubled, so sharpening of management practices is necessary, such as, for example, appropriate base fertilization (BATTISTI *et al.*, 2018).

Base fertilization can be carried out through the adoption of fertilizer formulations with distinct features, such as composition and pathway of nutrient release. In this context, mineral fertilizers, organomineral fertilizers, and slow release mineral fertilizers are highlighted (ZONTA *et al*., 2021). Mineral fertilizers mixed to soil ameliorants, such as granulated gypsum, at the sowing furrow have become a recent target of discussion (CASSOL; JÚNIOR, 2018).

Mineral fertilizers originate from mineral products, natural or synthetic, providers of one or more plant nutrients, and present features such as high reactivity and concentration. Organomineral fertilizers are the resultant of the physical mixture or combination of mineral and organic fertilizers (DIAS; FERNANDES, 2006), highlighted for being less soil reactive, performing progressive nutrient solubilization, stimulating microbial activity, and decreasing phosphorus fixation (SÁ *et al.*, 2017). Slow release mineral fertilizers are coated with resin and released to plants progressively through pores, being denominated pelletized, chemically altered, and also recoated (BRONDANI *et al.*, 2008). Agriculture gypsum is featured for supplying calcium and also sulfur, which is absent from mineral fertilizers (MODA *et al.*, 2013), and when available in granulated formulation may generate ease of transport, handling, and distribution (CAIRES; JORIS, 2016).

When any of the abovementioned alternatives is adopted for base fertilization, besides biometric and grain yield performance, it is important to quantify the alterations triggered in soil quality indicators (CHERUBIN *et al.*, 2015). Although chemical soil indicators are the most commonly used, they should be associated with microbiological indicators, which have the ability to provide quicker responses regarding the soil quality. More than this, analyzing a group of indicators allows precise responses to be gathered about alterations that occur in the soil environment.

It is further highlighted that quality indicators might contribute to more precise adoption of best fertilizer management practices, taking into account the right source, rate, time, and place, which together affect crop yield (JOHNSTON; BRUULSEMA, 2014). These practices, besides helping match crop nutrient requirements and preventing nutrient losses are of great importance to reduce expenses with fertilizers and also to maintain preservation of natural resources, contributing to the sustainability of agriculture production systems (FIXEN, 2020).

Based on the above, the current study had the goal of assessing alterations in the chemical and microbiological soil indicators, in the short term, as well as the soybean biometric and grain yield performance as a function of different fertilizers for base fertilization, in two sowing periods.

Material and methods

Description of experimental area

An experiment was carried out with two sowing periods in the 2019/2020 season, in north Parana state, with the geographical coordinates 23°20'21"S, 51°12'39"W, and a height of 572 m. The area had been cultivated under a no tillage system with soybean and wheat in succession, for three years, with the soil classified as dystrophic Red Latosol (EMBRAPA, 2018), with a clay texture and good drainage.

The regional climate, according to the Köppen classification, is Cfa, described as humid subtropical, with a warm summer, presenting infrequent freezing, and trend for the rain to be concentrated in summer months, however without a defined dry season (NITSCHE *et al.*, 2019). Meteorological data referring to the two sowing periods of the experiment originated from the Institute of Parana Rural Development (IDR) (Figures 1a and 1b). For the 1st sowing period, sown on 21/11/2019, (Figure 1a), the accumulated value of precipitation, and maximum and minimum average temperatures were 548.3 mm, 29.6 °C, and 19.1 °C, respectively. For the 2nd sowing period, sown on 07/12/2019, (Figure 1b), the values were 570 mm, 29.6 °C, and 18.3 °C, respectively.

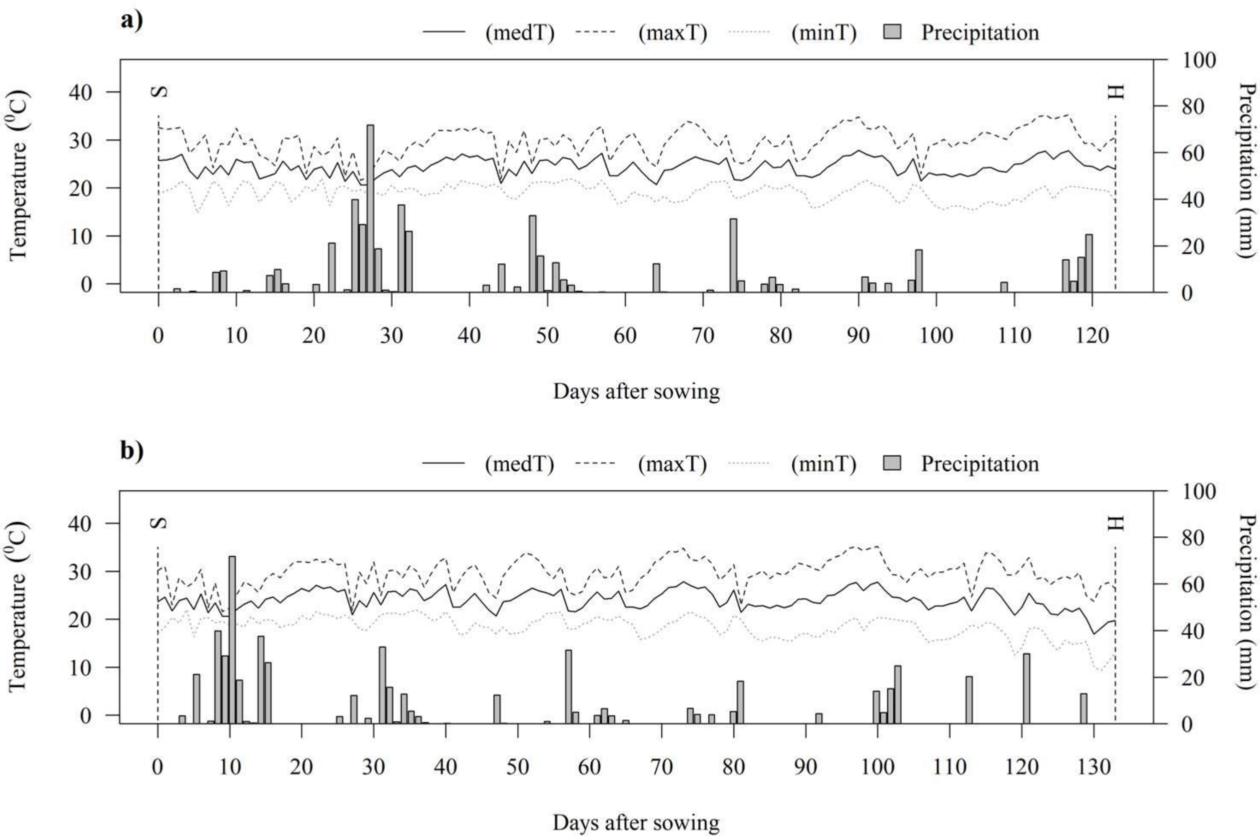

Figure 1. Meteorological data referring to the 1st (a) and 2nd (b) soybean sowing periods: S: sowing; H: harvesting.

Before sowing on each sowing period, twenty soil subsamples were collected from the area in the 0-10 cm depth layer, which were homogenized to result in a single sample, which was utilized for soil chemical characterization of the experimental area (Table 3).

Experimental design

The randomized complete block design was adopted, comprising five treatments (Table 1) and four replicates. Each experimental unit was made up of six 5 m rows, spaced at 0.45 m, totaling

13.5 m^2. To define the useful area, the two central rows of the plot were considered, discounting 1.0 m from the ends, totaling 2.7 m^2.

Treatments employed

Treatments were adjusted to provide 80 kg P_2O_5 ha^{-1}, the reference rate for phosphorus, aiming to reach a grain yield of 5 tons ha^{-1}, according to soil chemical analysis (Table 3), and following technical recommendations (PAULETTI; MOTTA, 2017). For the treatment comprised of granulated gypsum, the rate applied to the mineral fertilizer was calculated, intending to supply 60 kg Ca ha^{-1}, and taking into account that 12.2 kg Ca is needed for each soybean grain ton produced (EMBRAPA, 2014). This same rate provided 50 kg S ha^{-1}.

Table 1. Treatments employed, formulas, and quantities utilized to complete the standard rate of 80 kg P_2O_5 ha^{-1}.

[1]TREATMENT	Formula (N-P_2O_5-K_2O)	Rate of formula (kg ha^{-1})	Rate of P_2O_5 (kg ha^{-1})
CONT	no fertilization	-------	-------
ORG	02-10-05	266.6	80
M	11-52-00	153.8	80
M+GG	11-52-00 + (16% Ca + 13% S)	153.8 + 380	80
SRM	09-38-00	210.5	80

[1]Treatments: CONT (control); ORG (organomineral added to 8% Ca + 3% Mg, chemical equivalent of the mineral 04-30-10); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral added to 18% S + 0.15% B + 0.15% Cu + 0.45% Mn + 0.45% Zn).

Implementation and conduction

Fertilizer distribution was carried out manually in the sowing furrow in each plot, after it had been mechanically opened by means of an experimental plot sowing planter made of six row units. Once distributed, fertilizers were immediately manually covered in order to prevent their contact with the seeds. Sowing was carried out right after this process.

Sowings were carried out on two dates, 21/11/2019 and 07/12/2019, which are within the recommended intervals for the crop region, according to information available on the Zarc – Plantio Certo app (EMBRAPA, 2019). At the sowing moment, seeds were inoculated with liquid inoculant, which contained the biological nitrogen fixation bacteria *Bradyrhizobium japonicum*, with a concentration of 5.0 x 10^9 viable cells per mL, at a rate of 100 mL 50 kg^{-1} of seeds.

The sowing process was semi-mechanized, with a disc hand planter. The soybean cultivar utilized was TMG 7062IPRO, with an average cycle for Parana state in regions above 500 m high, varying from 122 to 134 days. The number of seeds distributed was calculated based on the germination test, in order to achieve a population of eleven plants per linear meter (TMG, 2020). The final plant stand achieved in each treatment, as well as the percentage in relation to the desired plant stand, are shown in Table 2.

Table 2. Desired plant stand (DPS) and final plant stand (FS) achieved.

[1]TREATMENT	DPS	1st sowing period FPS	1st sowing period FPS/DPS	2nd sowing period FPS	2nd sowing period FPS/DPS
	plants ha^{-1}	plants ha^{-1}	(%)	plants ha^{-1}	(%)
CONT		237,037	97.0	212,037	86.7
ORG		228,703	93.6	205,555	84.1
M	244,444	238,888	97.7	204,629	83.7
M+GG		225,000	92.0	187,693	76.9
SRM		234,259	95.8	219,444	89.7

[1]Treatments: CONT (control); ORG (organomineral); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral).

Potassium fertilization was carried out through side-dressing at the V4 growth stage, for all treatments, with the exact amount of the potassium chloride fertilizer (60% K_2O) distributed by hand in each plot row at the rate of 150 kg ha^{-1} (PAULETTI; MOTTA, 2017).

Assessments carried out

Following full flowering, the soil was sampled at a depth of 0-10 cm by means of a probe, at one point in each inter-row plot, which resulted in one sample of each plot. These samples were utilized to assess the chemical (Table 3) and microbiological soil attributes (Tables 4 and 5).

For carbon microbial biomass (CMB) determination, the modified fumigation-extraction method of Vance, Brookes and Jenkinson (1987) was utilized; and for nitrogen microbial biomass (NMB) determination, the method proposed by Brookes *et al.* (1985). Basal respiration (BR), induced basal respiration (IBR), and the metabolic quotient (qCO_2) and induced metabolic quotient ($IqCO_2$) were determined through the method proposed by Anderson and Domnsch (1978).

The seeds from the 1st sowing period were harvested on 22/03/2020, while those from the 2nd sowing period, were harvested on 18/04/2020. At the harvesting moment, 20 plants in a row were collected within the useful area of each plot to assess the following components: first pod insertion height, plant height, stem diameter, number of pods per plant, number of grains per plant, number of grains per pod, mass of grains per plant, one thousand grain mass and grain yield, considering that for the last three components, the mass was corrected to 130 g of water per kilo of grain. Grain yield was obtained through summing the mass of the 20 plants harvested to the rest of the useful area of the plot, the latter being threshed on a stationary thresher.

Data analysis

Data were tested for normality of errors and homogeneity of variances, through the Shapiro-Wilk and ONeill and Mathews tests, respectively. Subsequently, they were submitted to analysis of variance and, when significance was detected, through the Tukey test. Each experiment was analyzed separately. For all analyses a 5% probability level was adopted, considering that all were run through R software (R CORE TEAM, 2020).

Results and discussion

There were no significant differences among treatments for any chemical attributes assessed ($pH_{(H2O)}$; $pH_{(KCl)}$, $pH_{(CaCl2)}$; $pH_{(SMP)}$; H+Al; Al^{+3}; Ca^{+2}; Mg^{+2}; K^{+}; P; $CEC_{(pH\ 7.0)}$; $CEC_{(effective)}$; OM; and N) in both the 1st and 2nd sowing periods (Table 3). Wyngaard *et al.* (2012) when working with fertilization experiments over ten years, or the medium term as considered by the authors, stress the importance of this kind of this study in the long term. However, based on other authors, they highlight that information on the medium term is essential from the standpoint that it allows comparisons between two or more contrasting situations, as well as providing knowledge about the direction and magnitude of the change triggered in the soil as a result of the management practice adopted.

Table 3. Chemical attributes in a dystrophic Red Latosol - initial chemical characterization and post-flowering of soybean in 1st and 2nd sowing periods.

Chemical analysis of soil characterization														
Depth	**[1]pH H_20**	**pH KCl**	**pH $CaCl_2$**	**pH SMP**	**H+Al**	**Al^{+3}**	**Ca^{+2}**	**Mg^{+2}**	**K^+**	**P**	**CEC pH 7.0**	**CEC effective**	**OM**	**N**
cm	**----------------------------------**				**$cmol_c$ dm^{-3}**					**mg dm^{-3}**	**$cmol_c$ dm^{-3}**		**%**	**g kg^{-1}**
0-10	5.7	4.6	4.9	5.7	6.1	0.1	7.0	1.8	0.9	32.9	15.8	9.8	3.4	1.9
[2]TREATMENT	**Post-flowering soil chemical analysis (0-10 cm) 1st sowing period**													
CONT	5.4	4.3	4.7	5.7	6.1	0.1	4.5	1.0	0.3	40.4	11.9	5.9	2.4	1.8
ORG	5.4	4.2	4.6	5.6	6.8	0.2	3.6	0.9	0.3	37.4	11.6	4.9	2.5	1.8
M	5.4	4.3	4.7	5.7	6.2	0.2	3.7	0.9	0.3	30.6	11.1	5.0	2.2	1.7
M+GG	5.4	4.3	4.7	5.8	6.0	0.1	4.1	0.9	0.3	32.9	11.3	5.4	2.6	1.7
SRM	5.4	4.2	4.6	5.8	6.0	0.1	4.1	1.0	0.3	32.5	11.3	5.5	2.5	1.7
AVERAGE	5.4 ns	4.2 ns	4.7 ns	5.7 ns	6.2 ns	0.1 ns	4.0 ns	0.9 ns	0.3 ns	34.8 ns	11.4 ns	5.3 ns	2.4 ns	1.7 ns
[3]CV (%)	0.9	2.6	1.4	2.4	10.2	89.4	17.1	17.4	13.9	34.8	4.0	13.9	9.1	4.2
[2]TREATMENT	**Post-flowering soil chemical analysis (0-10 cm) 2nd sowing period**													
CONT	5.3	4.3	4.6	5.8	5.7	0.1	3.9	0.8	0.2	24.9	10.6	5.0	2.3	1.6
ORG	5.3	4.2	4.5	5.7	6.1	0.1	3.5	0.9	0.2	42.2	10.7	4.7	2.3	1.6
M	5.3	4.2	4.6	5.7	6.1	0.2	3.2	0.7	0.2	28.8	10.3	4.3	2.3	1.7
M+GG	5.3	4.2	4.6	5.8	5.9	0.1	3.7	0.8	0.2	28.1	10.6	4.8	2.3	1.7
SRM	5.3	4.2	4.6	5.8	5.9	0.1	3.6	0.8	0.3	30.3	10.5	4.7	2.1	1.7
AVERAGE	5.3 ns	4.2 ns	4.6 ns	5.8 ns	5.9 ns	0.1 ns	3.6 ns	0.8 ns	0.2 ns	30.9 ns	10.5 ns	4.7 ns	2.3 ns	1.7 ns
[3]CV (%)	1.2	2.9	1.1	2.5	10.9	97.4	19.5	15.8	12.1	33.6	4.9	15.8	10.9	7.2

[1]pH in KCl 1N; pH in $CaCl_2$ 0.01 mol L^{-1}; potential acidity (H+Al) by SMP; exchangeable acidity (Al^{+3}) in KCl 1 mol L^{-1} by titration with NaOH 0.01 mol L^{-1}; exchangeable calcium (Ca^{+2}) and exchangeable magnesium (Mg^{+2}) extracted by KCl 1 mol L^{-1} and reading through spectrophotometer of atomic absorption; exchangeable potassium (K^+) and available phosphorus (P), with extraction by Melich-1 and readings in flame photometer and spectrophotometer in 630 nm, respectively; cation exchange capacity (CEC); organic matter (OM) based on organic carbon; and N by Kjeldahl method, by steam distillation. [2]Treatments: CONT (control); ORG (organomineral); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral). [3]CV: coefficient of variation; ns: not significant.

It is possible to note in Table 4, that there was no difference among treatments for CMB in the two sowing periods. The greatest values for NMB in the 1st sowing period were obtained for treatments in which fertilizers contained the highest nitrogen concentrations (M; M+GG; SRM), which influenced, therefore, the CMB/NMB ratio, causing a reduction in this factor. It is suspected that this decrease is related to the fact that wheat was the previous crop culture. Straw of crop grasses are characterized as having a high C/N ratio (GAZOLLA *et al.*, 2015), which might trigger a great mineral nitrogen immobilization by microbial biomass during its decomposition, as observed by Kayser, Selbach and Sá (2005). The same authors assessed nitrogen immobilization on the corn crop in a corn-black oat succession, and claimed that as the black oats have a high C/N ratio, the microbial biomass when utilizing it as a carbon source for energy generating, had to make use of both the organic nitrogen present in the black oat residue as well as the mineral nitrogen in the soil. The values were statistically equal in the 2nd sowing period for NMB, thus not altering the CMB/NMB ratio. This result might be related to the high precipitation volume in the first ten days after sowing, which totaled 94.8 mm (Figure 1b), and may have caused loss of nitrogen from fertilizers through leaching, decreasing their microbial incorporation. Alterations such as these highlight the importance of monitoring microbial biomass in different soil management systems, as, besides acting as a nutrient reservoir to plants, it interacts with soil particles and performs numerous biological and biochemical processes essential to ecosystem maintenance (ALMEIDA; SANCHES, 2014).

Table 4. Carbon and nitrogen of microbial biomass (CMB and NMB) and CMB/NMB ratio in a dystrophic Red Latosol submitted to different base fertilization practices in soybean crop culture.

[1]TREATMENT	1st sowing period			2nd sowing period		
	CMB	*NMB	(CMB/NMB)	CMB	NMB	(CMB/NMB)
	(mg kg^{-1})			(mg kg^{-1})		
CONT	286.6	24.8 c	11.6 a	348.9	46.9	8.2
ORG	295.4	54.5 b	5.5 b	312.8	32.8	10.8
M	317.2	91.9 a	3.5 c	367.2	38.4	14.2
M+GG	260.6	83.5 a	3.1 c	351.1	38.0	9.5
SRM	298.0	88.9 a	3.4 c	307.5	44.4	7.3
AVERAGE	291.5 ^{ns}	68.7	5.4	337.5 ^{ns}	40.1 ^{ns}	10.0 ^{ns}
[2]CV (%)	8.6	9.2	15.2	13.0	29.3	54.7

[1]Treatments: CONT (control); ORG (organomineral); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral). [2]CV: coefficient of variation; ^{ns}: not significant. *: averages followed by the same letter in the column are considered statistically equal by the Tukey test at 5% probability.

According to Table 5, BR, IBR, BR/IBR, qCO_2, and $IqCO_2$ responded similarly as a function of the different treatments in the 1st sowing period. However, when observing the results of the 2nd sowing period, it is possible to note that the ORG treatment promoted greater BR, which triggered a greater BR/IBR ratio, stressing that microorganisms, due to lack of carbon, were stimulated by glucose addition, highlighting the resilience and its potential response under favorable conditions (BABUJIA *et al.*, 2010). It can also be highlighted that the greater BR observed reflects the highest microbial biomass activity, which in the short term, might indicate greater nutrient release to the plants (MOURA *et al.*, 2015). Furthermore, in Table 5, in the 2nd sowing period, for the ORG treatment, higher qCO_2 was observed. Greater qCO_2 values indicate an increase in the stress condition or microbial disturbance (GODOY *et al.*, 2013), more than this, it implies low efficiency of the process, which means a lower carbon incorporation rate by microbial biomass, as the greatest qCO_2 values reflect greater CO_2 lost to the atmosphere (EVANGELISTA *et al.*, 2013).

Table 5. Basal respiration (BR), induced basal respiration (IBR), basal respiration to induced basal respiration (BR/IBR) ratio, metabolic quotient (qCO_2), and induced metabolic quotient ($IqCO_2$).

[1]TREATMENT	*BR	IBR	*BR/IBR	*qCO_2	$IqCO_2$
	(μg C-CO_2 g^{-1} CMB day^{-1})			(mg C-CO_2 g^{-1} CMB day^{-1})	
	1st sowing period (21/11/2019)				
CONT	8.94	50.05	0.18	31.48	175.57
ORG	7.19	52.00	0.14	25.00	177.33
M	6.34	48.13	0.13	19.97	151.78
M+GG	7.52	50.92	0.15	29.00	195.72
SRM	7.20	49.18	0.15	24.65	166.53
AVERAGE	7.44 ns	50.06 ns	0.15 ns	26.00 ns	173.39 ns
[2]CV (%)	24.94	6.98	25.61	30.93	10.30
	2nd sowing period (07/12/2019)				
CONT	4.53 cd	24.06	0.19 cd	13.21 b	69.62
ORG	11.20 a	28.30	0.40 a	37.25 a	96.38
M	6.88 bc	25.53	0.27 bc	18.83 b	69.86
M+GG	8.07 b	27.99	0.29 b	23.20 b	80.74
SRM	4.13 d	28.84	0.14 d	13.46 b	94.74
AVERAGE	6.96	26.94 ns	0.26	21.19	82.27 ns
[2]CV (%)	15.81	16.69	14.39	24.35	25.65

[1] Treatments: CONT (control); ORG (organomineral); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral). [2]CV: coefficient of variation; ns: not significant. *: averages followed by the same letter in column are considered statistically equal by Tukey test at 5% probability.

There was no significant effect among treatments for the biometric features and yield components assessed in the two sowing periods (Table 6). It was suspected that in the 1st sowing period the greatest NMB obtained in the treatments M; M+GG; SRM (Table 4) would possibly have favored soybean crop development according to nitrogen mineralization, which was not observed. Coser *et al.* (2007) highlight that the necessary time for NMB to be released into the environment is ten times greater than the vegetable material under decomposition, a fact that may have contributed to the obtained results. It was also thought that in the 2nd sowing period the greater microbial activity represented by BR in the ORG treatment (Table 5), due to the increase in nutrient cycling, could possibly contribute to plant development, which was not observed. According to Sá *et al.* (2017), organomineral fertilizers are important for their progressive and slow release, which might have influenced the results.

The average grain yields obtained in the two sowing periods (Table 6) were lower than the state average (3595 kg ha^{-1}) and national average (3523 kg ha^{-1}) (CONAB, 2021). These results may be explained partly by the fact that the final stand achieved was lower than the one recommended for the cultivar, of 244,444 plants ha^{-1} (Table 2) (TMG, 2020). In addition, it is worth considering that the two sowing periods are considered late, since the sowing period for the cultivation region with a risk of 20% comprises the interval between the first ten days of October and the last ten days of December (EMBRAPA, 2019). According to Carmo *et al.* (2018), the sowing period has a great influence over morphological features and grain yield components, in such a way that late sowings allow for lower grain yield.

Table 6. Biometric features: first pod insertion height (FPIH), plant height (PH), stem diameter (SD); and yield components: number of pods per plant (NPPL), number of grains per plant (NGPL), number of grains per pod (NGP), mass of grains per plant (MGPL), one thousand grain mass (OGM) and grain yield (GY).

[1]TREATMENT	FPIH (cm)	PH (cm)	SD (mm)	NPPL	NGPL	NGP	MGPL (g)	OGM (g)	GY kg ha^{-1}
1st sowing period (21/11/2019)									
CONT	22	84	6.4	40	70	1.8	11	163	2625
ORG	21	81	6.4	38	68	1.8	11	163	2537
M	23	76	6.3	33	60	1.8	10	169	2333
M+GG	24	89	6.9	39	71	1.8	12	171	2461
SRM	24	88	6.8	39	71	1.8	12	166	2524
AVERAGE	23 ^{ns}	83 ^{ns}	6.5 ^{ns}	38 ^{ns}	68 ^{ns}	1.8 ^{ns}	11 ^{ns}	167 ^{ns}	2496 ^{ns}
[2]CV (%)	7.2	10.3	8.9	22.7	20.1	7.2	23.5	6.6	17.1
2nd sowing period (07/12/2019)									
CONT	12	45	4.7	23	38	1.7	5.9	157	1322
ORG	10	48	5.5	33	54	1.7	9.0	171	1612
M	11	49	5.4	31	53	1.7	8.7	164	1496
M+GG	11	50	5.4	30	49	1.7	8.5	170	1517
SRM	12	49	5.3	28	49	1.8	7.7	163	1631
AVERAGE	11 ^{ns}	48 ^{ns}	5.2 ^{ns}	29 ^{ns}	48 ^{ns}	1.7 ^{ns}	7.9 ^{ns}	165 ^{ns}	1516 ^{ns}
[2]CV (%)	10.3	11.1	8.5	17.9	17.9	5.2	20.5	7.8	14.7

[1]Treatments: CONT (control); ORG (organomineral); M (mineral); M+GG (mineral mixed to granulated gypsum); SRM (slow release mineral). [2]CV: coefficient of variation; ^{ns}: not significant.

Considering average grain yield among treatments in the present work, decreases of 980 kg ha^{-1} were observed between the 1st sowing period and 2nd sowing period (16 day interval), which is equivalent to a decrease of 61 kg ha^{-1} day^{-1}, which must be carefully observed as the final plant stand in the 2nd sowing period was lower in relation to the 1st sowing period. Similar grain yield performance was also observed by other authors working with sowing period trials, such as the one performed by Santos and Cecatto (2018). With sowing being carried out on the dates 21/11/2015 and 04/12/2015, approximately the same as the present study, the authors obtained grain yields of 2446 and 1402 kg ha^{-1}, respectively, these values referring to the average of five soybean cultivars.

Soybean maximum grain yield potential is the result of the sum of several factors, namely the climatic conditions, which are variable as a function of different sowing periods, and the growing environment (BARBOSA *et al.*, 2013). Based on this, in search for technical adjustments that culminate in the best soybean crop culture performance, studies with a regional approach, or even at the rural property level, might contribute to greater data set and, hence, more accurate decision making.

Conclusions

There is no base fertilization effect on the soil chemical indicators in the short term, however, there is an effect on the microbiological soil indicators.

Soybean biometric and grain yield performance is decreased with delayed sowing period, regardless of the type of fertilizer utilized for base fertilization.

Analyzing a set of soil quality indicators enables precise and judicious results to be gathered on management practices in soil environment.

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