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ASPECTOS AGRONÔMICOS DE FEIJÃO-COMUM À ADUBAÇÃO ORGANOMINERAL POTÁSSICA SOB DÉFICIT HÍDRICO

RENATO AUGUSTO PAMPLONA PEREIRA[1]; LUCAS DADA CARASCOSA[2]; OLAVO PIMENTEL SILVA[3]; RENAN DE OLIVEIRA SILVA[4]; MARCELO AUGUSTO SILVA TINEU[5] E HÉLIO GRASSI FILHO[6]

[1]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. rap.pereira@unesp.br ORCID: (https://orcid.org/0000-0003-3944-2431)
[2]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. lucas.d.carascosa@unesp.br. ORCID: (https://orcid.org/0009-0003-2511-125X)
[3]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. olavo.pimentel@unesp.br ORCID: (https://orcid.org/0000-0001-7996-0079)
[4]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. renan.o.silva@unesp.br. ORCID: (https://orcid.org/0009-0008-3898-1648)
[5]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. marcelo.tineu@unesp.br. ORCID: (https://orcid.org/0009-0005-1306-3849)
[61]Departamento de solos e recursos ambientais- FCA- UNESP. Brasil. heliograssi@fca.unesp.br ORCID: (https://orcid.org/0000-0002-9533-4067)

1 RESUMO

A pesquisa investigou os efeitos da adubação organomineral potássica em feijão comum (*Phaseolus vulgaris*) submetido a estresse hídrico. O estudo foi conduzido em casa de vegetação da Faculdade de Ciências Agronômicas – da UNESP-Botucatu, utilizando um latossolo vermelho-amarelo de textura média. O delineamento experimental foi inteiramente casualizado, com esquema fatorial 2x6 (duas fontes de potássio: fertilizante organomineral cloreto de potássio (KCL); e seis doses: 0, 50, 100, 150, 200 e 250 kg ha^{-1}), com quatro repetições. O manejo de irrigação foi realizado por gotejamento, com base na curva de retenção de água do solo e monitoramento da umidade por tensiômetros. As variáveis agronômicas avaliadas foram área foliar, massa verde, massa seca da parte aérea e número de vagens. Os resultados demonstraram que a adubação com fertilizante organomineral especialmente em doses mais elevadas, promoveu aumento significativo na área foliar, massa seca e número de vagens, superando os efeitos do KCl. As plantas tratadas com fertilizante organomineral também apresentaram maior tolerância ao estresse hídrico, evidenciando o potencial desse fertilizante na melhoria da produtividade do feijão em condições de escassez hídrica.

Palavras-Chave: organomineral, estresse hídrico, *Phaseolus vulgaris*.

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AGRONOMIC ASPECTS OF COMMON BEAN UNDER ORGANOMINERAL POTASSIUM FERTILIZATION AND WATER DEFICIT

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2 ABSTRACT

Research has investigated the effects of organomineral potassium fertilization on common bean (Phaseolus vulgaris) under water stress. The study was conducted in a greenhouse at the Faculty of Agronomy - UNESP-Botucatu, using a medium-textured red--yellow latosol. The experimental design was completely randomized in a 2x6 factorial scheme (two potassium sources: organomineral fertilizer and potassium chloride (KCl) and six doses: 0, 50, 100, 150, 200, and 250 kg ha $^{-1}$), with four replications. Irrigation management was carried out via drip irrigation on the basis of the soil water retention curve, and moisture was monitored with tensiometers. The agronomic variables evaluated were the leaf area, fresh mass, dry mass of the aerial part, and number of pods. The results revealed that fertilization with organomineral fertilizer, especially at relatively high doses, significantly increased the leaf area, dry mass, and number of pods, surpassing the effects of KCl. Plants treated with organomineral fertilizer also showed greater tolerance to water stress, indicating the potential of this fertilizer to improve bean productivity under water scarcity conditions.

Keywords: organomineral, water stress, *Phaseolus vulgaris*.

3 INTRODUCTION

Potassium (K) is especially important for all crops, mainly because it is linked to the physiological activities of plants. Potassium fertilization is essential in soils with low natural availability of potassium or in situations where crops have a high demand for this nutrient, such as during phases of rapid growth, fruit formation and root development (Faquin, 2005).

The supply of this element to plants contributes to their growth, especially in situations of water deficit, by regulating the osmotic balance, stimulating stomatal opening and actively participating in enzyme activation, as well as the formation of reproductive organs (Faquin, 2005; Malavolta, 2006). Efficient management of potassium fertilization is essential to ensure that plants receive an adequate amount of this nutrient, thus promoting more productive and sustainable agriculture (Vargas, 2012).

Over the past five years, common bean production in Brazil has faced challenges and fluctuations, which are influenced mainly by climatic factors, increased production costs and changes in market demand. Despite this, common bean remains a relevant crop for Brazilian agriculture, with millions of tons produced annually. In the 2023/24 harvest, bean production reached 3,259 thousand tons (Feijão, 2024).

The relationship between potassium and common bean traits has been studied over the years, especially in terms of seed quality and physiological performance, especially in terms of photosynthesis in plants under saline stress and in the resistance of common bean plants under water stress conditions (Carvalho *et al.*, 2022; Meira *et al.*, 2020; Magalhães *et al.*, 2021). Potassium fertilization plays a fundamental role in bean production, especially under water stress conditions. By improving water use efficiency and increasing salt tolerance, potassium contributes to increased grain productivity and quality (Malavolta, 2006).

Therefore, organomineral potassium fertilizers have emerged as alternative mineral sources of potassium, aiming to optimize plant nutrition and improve soil health. These fertilizers provide a series of benefits both in agronomic issues and in environmental demands, since they are a viable option for reducing the deleterious effect of the saline index through the use of organic materials in the soil, with a lower polluting effect. (Malavolta, 2006).

Therefore, this research sought to investigate the supply of potassium to plants in two forms: organomineral fertilizer (FOM) in parallel with the conventional source (KCl) and its physiological effects during the bean production cycle and its final yield.

4 MATERIALS AND METHODS

4.1 Study location

The research was developed in the greenhouse of the Soils and Environmental Resources, belonging to the Faculty of Agricultural Sciences – UNESP, Botucatu/SP, Brazil.

4.2 Soil characteristics

The soil used is classified as Red–Yellow Latosol with a medium texture and was previously subjected to a sieving process before sowing common beans.

The physical–chemical characterization of the soil was carried out at the Soil Chemistry Laboratory of the Department of Soils and Environmental Resources, belonging to the Faculty of Agricultural Sciences – UNESP, Botucatu/SP, Brazil, and this method was used to correct acidity and manage fertilization (Table 1).

Table 1. Chemical analysis of the soil used in the experiment

pH	MO	P. resin	Al^{3+}	H+Al	K	Here	Mg	SB	CTC	V%
CaCl2	g/dm 3	----------------- mg/dm 3 ------------------------								
4.2	19	12	51	-	2.0	10	17	19	70	27

Micronutrients

S	B	Faith	Mn	Zn
----------------- mg/dm 3 ------------------------				
17	0.32	29	12.3	0.8

Source: The authors (2025).

4.3 Liming and Fertilization

The soil correction method was performed by base saturation, since the soil analysis verified a CTC of 70% and a V% of 27. Therefore, according to the recommendations of Bulletin 100 of the State of São Paulo (Cantarella *et al.*, 2022), liming should be carried out to increase the base saturation content (V%) to 70% and the Mg content to a minimum value of 8 mmolc dm $^{-3}$ for the cultivation of common beans, expecting a productivity of 4.5 t ha $^{-1}$. Therefore, when the values were substituted, 4.3 t ha $^{-1}$ limestone was found to be used (PRNT 70%). Liming was carried out 30 days before planting, with approximately 11.2 g of limestone being applied to each pot (with a volume of 18 l) at an incorporation depth of 5 cm, considering a pot area of 0.16 ^{m2}.

After liming, 45 kg ha $^{-1}$ N was applied for the expected productivity of 4 t ha $^{-1}$ at a fertilizer dose of 100 kg ha $^{-1}$ (urea) during planting, and P2O5 (super single phosphate) was applied at a dose of 140 kg ha $^{-1,}$ which is recommended for beans before planting, with a maximum production of 5 T ha $^{-1}$ (Cantarella *et al.*, 2022). When the dose per pot was transformed, values of 1.6 and 2.24 g pot $^{-1}$ were obtained for N and P, respectively.

4.4 Chemical characteristics of fertilizers

The study involved the use of two types of potassium fertilizers: one of organomineral origin (K2O) and the other mineral (KCl).

The chemical characteristics of the potassium fertilizers used during the experiment were analyzed. The samples were taken to the fertilizer laboratory of the Department of Soils and Natural Resources of the Faculty of Agricultural Sciences of UNESP-Botucatu. Table 2 below shows the properties of the organomineral fertilizer (OMF):

Table 2. Chemical analysis of organomineral fertilizer

Nutrients	**% (natural)**
N	0.52
P_2O_5	1.17
K_2O	16.06
Here	1.97
Mg	0.17
S	5.18
Humidity	2
MO	15
	mg/kg (natural)
CO	8
In the	10442
B	156
Ass	16
Faith	24561
Mn	169
Zn	61
Rel. C/N	15/1
pH	6.4

Source: The authors (2025).

Chemical analysis of the mineral fertilizer (FM) revealed only 57% potassium chloride (KCl), whereas the organomineral fertilizer presented 16.06% K2O.

4.5 Irrigation management

For the irrigation management of the experiment, the water retention curve (Equation 1) was determined for the soil in question via the Genuchten model (1980) with the Soil computer program. Water retention curve (SWRC) version 3.0 Beta (Dourado Neto; Reichardt; Nielsen, 2001). The values of moisture at field capacity (θ CC, – 10 kPa) and the permanent wilting point (θPMP, – 1,500 kPa) were 0.428 and

0.162 cm ^{3} cm $^{-3,}$ respectively. The irrigation moment was defined by tensiometry, where through an electronic pulse tensimeter, the water tension in the soil was measured until the water potential reached -40 kPa.

$$\theta = 0{,}47/[1 + (1.24\ \psi m)^{2.945}]^{0.185} + 1 \quad (1)$$

where θ represents the soil moisture in cm ^{3} cm ^{3} and ψm represents the soil water matric potential in kPa.

Therefore, as the irrigation management used in the project was through localized irrigation, a 4 lh–1 flow rate dripper was placed in each pot . Before the flowering period, the irrigation time was determined to ensure that the water pressure in the soil did not exceed 15 kPa, which corresponds to 31% of the water content in the CAD. After that, the irrigation shift during the flowering period occurred when the water pressure in the soil reached 40 kPa, equivalent to 66.67% of the CAD. The irrigation time for each stage was approximately 7.92 minutes during the growth phase and 31.92 minutes during the flowering phase.

4.6 Statistical Design

The experiment was carried out in a completely randomized design with a 2x6 factorial design and 4 replicates. Two plants were grown per pot, with a capacity of 18 liters. The fertilizer treatments consisted of six doses for each type (FOM and KCL) in addition to the control treatment, with the following doses: 50, 100, 150, 200 and 250 kg ha $^{-1}$, incorporated into the soil at a depth of 5 cm.

The agronomic variables studied were leaf area (cm2), green mass (g), dry mass (g), and number of pods. A scale was used to measure the leaf area of the plants so that the length and width of all the leaves per pot could be measured. The aerial parts of all the plants were removed and weighed on a precision scale. After the green mass was weighed, all the samples were dried in a controlled drying oven at 65 °C for 24 hours to measure the dry mass. The number of pods per treatment was manually counted after the end of each cycle. All collected variables were tabulated and analyzed via the statistical software GraphPad Prism 8, where the ANOVA test was performed at 5% significance for all studied variables.

5 RESULTS AND DISCUSSION

A summary of the analysis of variance was carried out for all variables studied to date, verifying the mean squares and the coefficient of variation (CV) according to Table 3.

Table 3. Summary of analysis of variance for leaf area (cm ^{2}), green mass (g), dry mass (g) and number of bean pods subjected to potassium fertilization under water deficit

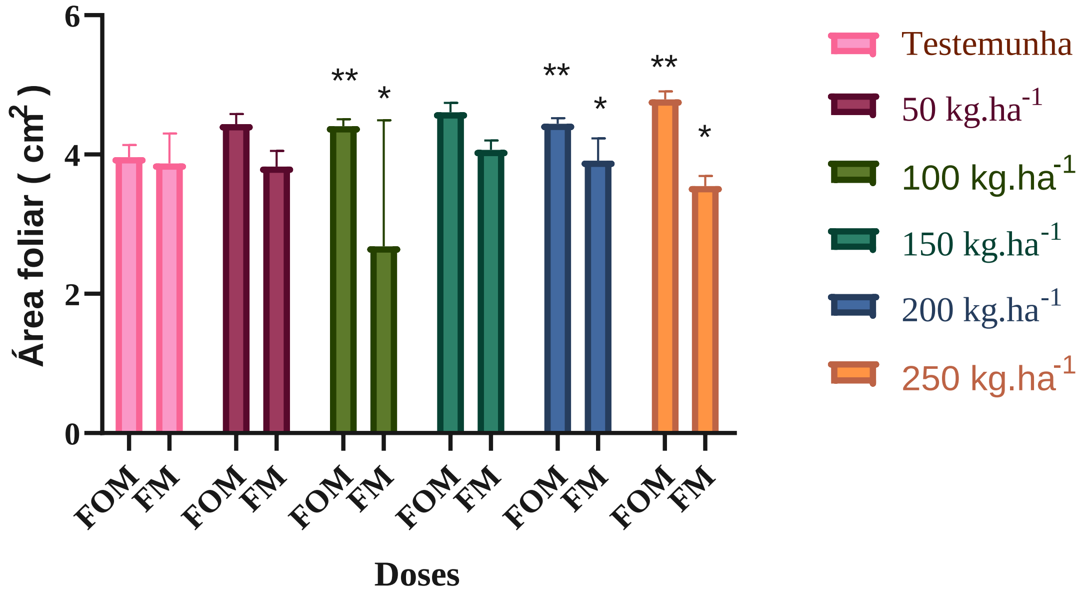
		Mean squares			
Source of Variation	**GL**	**Leaf area**	**Green mass**	**Dry pasta**	**Pod number**
Dose	11	us	43.36*	151.40*	227.4*
Source	1	7.5*	20.92*	209.36*	27.01*
Dose* Source	11	us	us	87.90*	us
Treatment	23	7.72	31.69	44.19	448.2
Waste	24	14.36	10.56	14.18	3
Total	47	8.4	24.08	39.04	44.2
CV (%)	-	34.23	34.18	39.0	24.29

GL: degree of freedom; CV (%): coefficient of variation; *: significant according to the F test at 1% probability.
Source: The authors (2025).

5.1 Leaf area

The graph of the average leaf area used to verify whether there were significant differences in the growth of the leaf area between the different doses and sources of fertilizer is shown in Figure 1.

Figure 1. Tukey test at 0.05% was performed for the leaf area of common bean subjected to different doses of organomineral potassium fertilizer under water deficit conditions.



Caption: Means marked with ** demonstrate significant differences according to the Tukey test at the 0.05% significance level compared with the means marked with *.

The comparison of the average took into account only the corresponding doses between the sources, and the results revealed that there was a significant difference in the increase in leaf area among the doses of 100, 200 and 250 kg ha^{-1}. The beans fertilized with the organomineral (FOM) doses presented greater values of leaf area, which were superior to those of the other treatments.

Sousa *et al.* (2014) reported that there was no difference in the leaf area or number of leaves of beans when a biostimulant was used as a fertilizer source. This result differs from the results obtained in this research when increasing doses of potassium were applied to the soil. However, the work of Sousa *et al.* (2014) demonstrated a significant difference in leaf area between plants irrigated with saline water and those irrigated with different doses of potassium chloride.

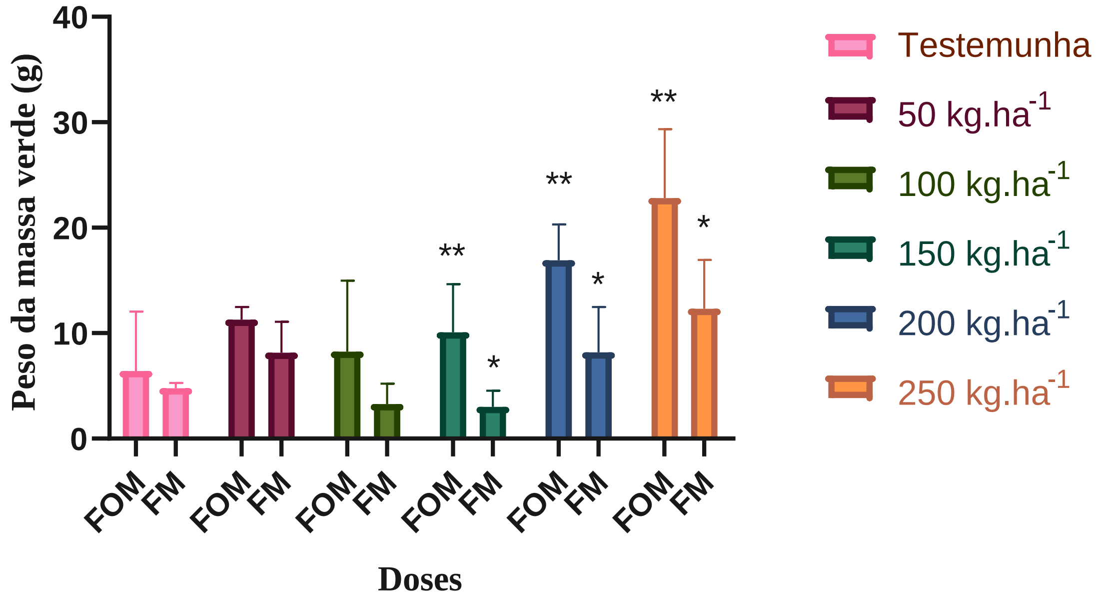
One factor to be considered is that the potassium present in the doses of the organic-mineral fertilizer used may have experienced slow and gradual release due to the presence of other nutrients in the organic matter that makes up the fertilizer, since the mineral fertilizer only has KCl in its composition, causing less loss of nutrients through leaching, making the nutrients better used by the plant throughout its cycle (Bittencourt, 2006; Flores; Macaringue; Gilengue). , 2022)

This result disagrees with that of Prazeres *et al.* (2015), who reported that even under different doses of potassium in the soil, bean plants did not show any difference in leaf area growth when only KCl was used as a source of potassium fertilization in the soil. However, when irrigation was carried out with saline water, a significant difference was observed. Compared with the other KCl doses, the treatments that resulted in a difference in leaf area between 5 and 10 cm2 resulted in greater leaf area at the FOM doses. This increase in leaf area was also reported by Pereira *et al.* (2013), who used organic material from cattle and goat manure as a source of fertilizer.

5.2 Green mass and dry mass

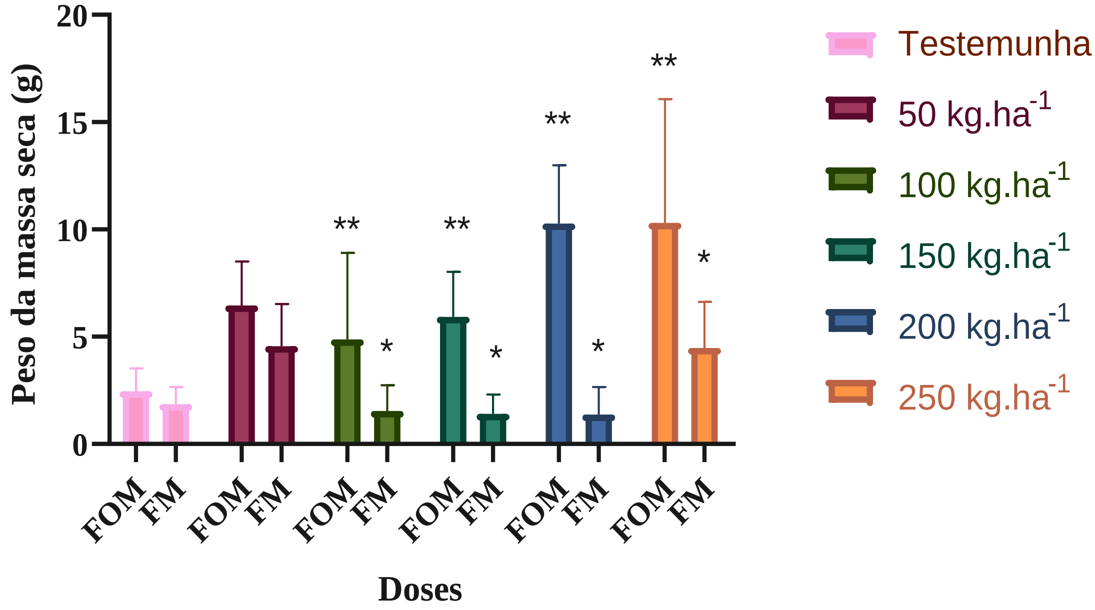
The results of the green mass and dry mass analyses demonstrated that there was a significant difference, as reported in Table 3. Therefore, the Tukey test (Figure 2) (Figure 3) was performed to determine which doses of both fertilizers presented a significant difference.

Figure 2. Tukey's test (0.05%) was performed on the MV variables of common beans subjected to different doses of organomineral potassium fertilizer under water deficit.



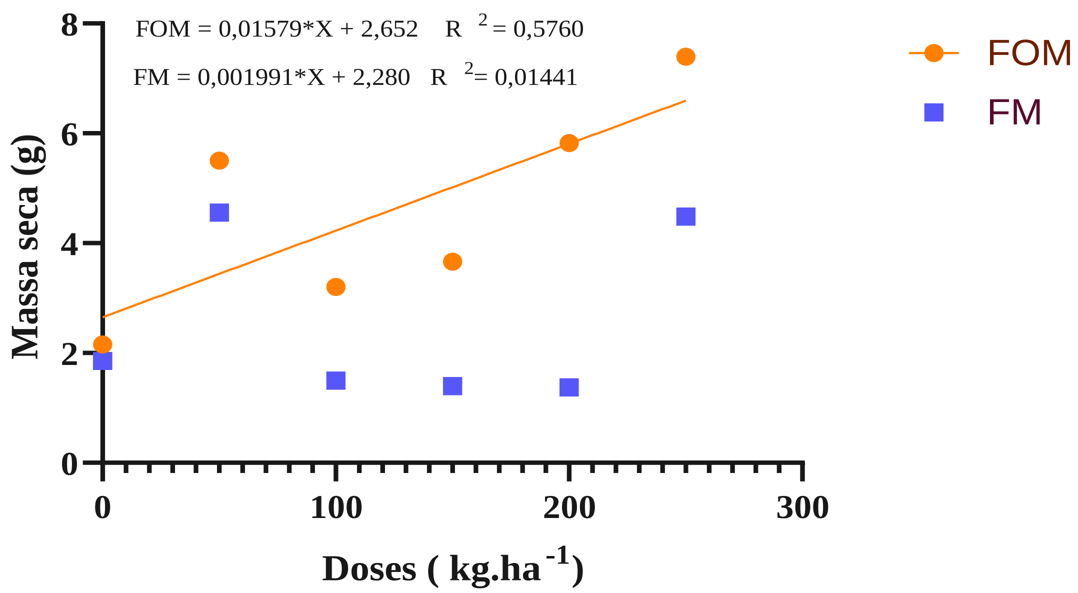
Caption: Means marked with ** demonstrate significant differences according to the Tukey test at the significance level compared with the means marked with *.

Figure 3. A 0.05% Tukey test was performed on the DM variables of common beans subjected to different doses of organomineral potassium fertilizer under water deficit.



Caption: Means marked with ** demonstrate significant differences according to the Tukey test at the significance level compared with the means marked with *.

Figure 4. Breakdown of the DosexFonte interaction for the dry mass of common beans subjected to different doses of organomineral potassium fertilization under water deficit



At the two lowest concentrations, there was no significant difference in the weight of either dry matter or green matter between the two sources. For the other doses (100, 150, 200, and 250 kg ha $^{-1}$), there was a difference between the fertilizer sources (FOM and KCL) for green matter; for dry matter, only the doses 150, 200, and 250 kg ha $^{-1}$ were used. These results corroborate the results obtained by Castro *et al.* (2020), where the application of different doses of FOM was more effective in the production of dry matter than the use of traditional mineral fertilizer (KCl). As shown in Figure

4, the dose of 200 kg ha $^{-1}$ appears to be more efficient for the production of dry matter. At this dose, the FOM reaches a value close to 6 g, whereas the FM is approximately 4 g. However, increasing the dose to 250 kg ha $^{-1}$ does not result in a significant increase in the FOM, and the FM remains practically unchanged.

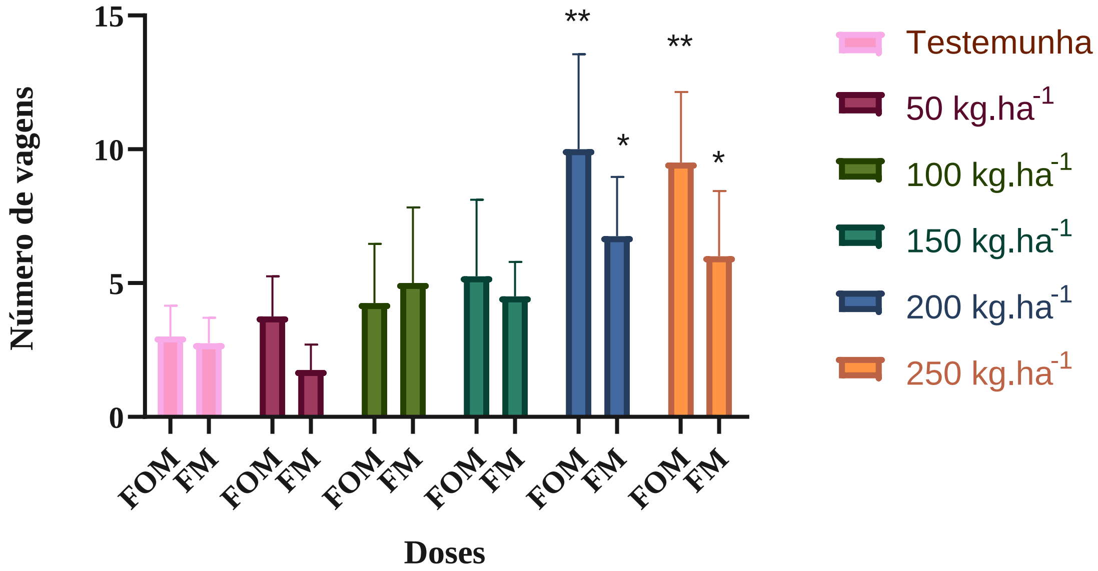
Clay and organic matter in the soil have negative charges, and as a result, the adsorption of K^{+} cations occurs (Malavolta, 2006). This would explain why FOM is more efficient at promoting plant growth than FM is. Amaral *et al*. (2015) studied increasing doses of potassium (KCl) applied to cowpea, and the green mass and dry mass were not significantly different.

In general, decreased growth in plants subjected to saline stress is a typical response, especially in glycophytes (Medeiros *et al.*, 2007; Silva *et al.*, 2008). This same trend was reported by Prazeres *et al.* (2014); when different forms of potassium fertilization were used, cowpea plants exposed to different salinity levels accumulated more dry matter in the aerial parts of the plants.

5.3 Number of pods

The data on the number of pods are shown in Graph 5 below:

Figure 5. Tukey test at 0.05% for the number of common bean pods subjected to different doses of organomineral potassium fertilizer under water deficit



Caption: Means marked with ** demonstrate significant differences according to the Tukey test at the significance level compared with the means marked with *.

Potassium is an important element for the translocation of nutrients, in addition to helping in the formation of flowers and fruits in all plants. Furthermore, it helps in regulating cell growth and division, a vital process for the formation of new plant tissues, especially floral ones (Malavolta, 2006). Therefore, from the results obtained, it is possible to note that the treatments that received a greater dose of FOM presented a greater number of pods, since this potassium released into the soil contributes to the formation of flowers during the reproductive phase.

The results revealed that the FOM doses of 200 and 250 kg ha $^{-1}$ presented averages of 10 to 12 pods per plant. The average number of pods in beans under water deficit may vary depending on the specific conditions of the study, the type of bean and the level of water stress applied. However, the literature indicates that water deficit has a significant effect on pod production. For example, Meira *et al.* (2020) and Brito *et al.* (2015) demonstrated that water deficit negatively affects yield in different bean species, with significant reductions in the number of pods formed under severe water stress conditions; however, under moderate water stress conditions, the number of pods per plant varies between five and 10. Therefore, it is necessary to emphasize that plants under adequate irrigation produce an average of 18 pods per plant compared with an average of 11 pods in plants under water stress (Hirich *et al.*, 2014).

The results obtained in the present study indicate that the FOM doses studied were not able to match the productive standard of the number of pods for the common bean crop, which is 38.89% less productive than that under normal water conditions.

6 CONCLUSIONS

Organomineral potassium fertilization has indeed proven to be a promising strategy for improving the productive performance of common beans under water stress conditions. The use of FOM at doses of 200 kg ha^{-1} and 250 kg ha^{-1} resulted in increases in the leaf area, dry mass, and number of pods, indicating greater efficiency in the use of available resources and greater tolerance to water deficit. However, additional studies are needed to determine the ideal dose of FOM to standardize productive yield with plants without water stress and to evaluate its effects under field conditions, aiming to optimize the use of this fertilizer in bean production and contribute to more sustainable agriculture in water scarcity scenarios.

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