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RESEARCH ARTICLE

DETERMINING THE OPTIMUM USE OF ROCK PHOSPHATE IN THREE LEGUMES (SOYBEAN, COWPEA AND GROUNDNUT) ON A LITHOSOL

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ABSTRACT

The low natural fertility of the soils, their poor anthropogenic management combined with the effects of climate change contribute to the low productivity of the soils and consequently to low agricultural yields in Burkina Faso. One of the solution to remedy is the use of Rock phosphate which is proves more economical and above all ecological to soil fertility hence the interest of this study wich aims to determine an optimum use Rock phosphate in legumes The study was carried out at Ralo in the commune of Poa on a block devise of Fisher has complete randomization with five repeats and two factors (legumes and fertilization) To do so, three species of legumes (soybeans with the G196 variety, cowpea with the melackh and groundnut with the Te3 variety), five doses of fertilization,namely,RP0 urea (14kg N/ha), RP100 urea and 14kg N/ha+100kg/ha,RP200 urea and 14kg N/ha+200kg/ha, RP400 urea and 14kg N/ha+400kg/ha and TSP urea and 14kg N/ha+23kg/ha were combined in this experiment. The parameters collected are the number of plants raised, the date of 50% flowering, the number of plants harvested, the weight of the guines, the weight of 100 seeds and the yield grams. The results of the health analysis (at the threshold of 5 ENT). Show a significant difference (p<0, 05) on all the parameters observed according to the legume factor of fertilization and of the treatments. The best performances in terms of seed weight, 100 grams and seed yield, cowpeas were observed with RP400, RP100, RP400 fertilizers those of soybeans were observed with RP200, RP100, RP200 fertilizers. Groundnut were observed with TSP fertilizers.

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INTRODUCTION

Seed legumes play a key role in most tropical countries (Dètongnon *et al.*, 2001). They play an important role in contributing to food security, income generation and environmental conservation for most producers in sub-Saharan Africa (TarawalI *et al.*, 2002). They are an important source of food for both humans and livestock, providing essential protein, mineral, fibre and vitamin requirements, and generating income through the sale of seeds and fodder. Through their ability to fix atmospheric nitrogen, they play an important role in soil fertility management. Among these legumes, cowpea (*Vigna unguiculata* (L) walp), groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) are the most important in most African communities where they are grown (Taffouo *et al.*, 2008). They therefore play a key role in crop rotation (Baudoin*et al.* 2001). However, despite the importance of leguminous crops, several constraints limit their production, including insect pests, diseases and low natural soil fertility, particularly phosphate deficiency. These constraints affect legume cultivation and limit yields.The importance of phosphorus in improving legume production and biological nitrogen fixation has been mentioned by several authors (Nandwa et al., 2011). However, population growth and ongoing soil degradation in tropical climates require the design of appropriate long-term management systems (Gauri,2019), in order to ensure and guarantee food security while ensuring, as Hervieu envisaged, "the right of peoples to feed themselves". Indeed, the use of rock phosphate (P.N) for direct application in the field may prove more economical and, above all, environmentally friendly. However, the effectiveness of rock phosphate (P.N) depends on its chemical and mineralogical composition, climatic factors, soil parameters and the crops to be grown (Gauri,2019). In order to contribute to the improvement of legume production by producing quality seeds and fodder, this study was carried out in the Centre-West region of Burkina Faso (Saria station) with the theme: "Determination of the optimum use of Rock phosphate by legumes on a lithosol". The general objective of this study is to evaluate the response of three legumes to rock phosphate fertilization on a lithosol. Specifically, it aims to i) Evaluate the amount of Rock phosphate required for each species; (ii) Find the most suitable species for each fertilization.

MATERIAL and METHODS

Study material

Presentation of the study area: Several types of soil were sampled in different agropedoclimatic zones of the country for the purposes of this study. A lithosol located at RALO was chosen. This locality is located in the centre-west region, in the Boulkiemdé province and in the Poa commune. With a population of 2913 (2003), its geographical coordinates are 12°11'42 "N, 2°09'36 "W. The site is under the influence of the northern Sudanian climate in a highly unstable environment due to strong human influence.

Plant material: The plant material used in this study is composed of three cultivated legume species: cowpea (variety melakh), soybean (variety G196) and groundnut (variety Te3). The cowpea and soybean varieties originate from Senegal, and the groundnut variety from Burkina Faso. The seeds (figure 1) were all supplied by the Institut de l'Environnement et de Recherches Agricoles (INERA). Table I below shows the characteristics of the varieties.

Figure 1. Seeds of three legume species (Legend: A: Te3; B: G196; C: Melakh)

Fertilizer materials: Three types of fertilizer were used (Figure 2), namely:

- Urea, with a chemical composition of 46% nitrogen in ammoniacal form;
- Triple Superphosphate (TSP), 46% phosphorus, including 44% water-soluble P205, 24% calcium and 4.5% sulfuric anhydride (SO3).
- Rock phosphate contains an average of 25% P2O5 and 35% CaO.

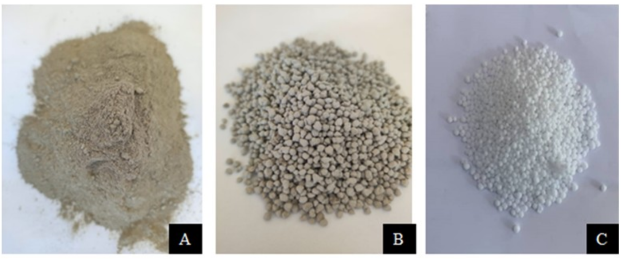

Figure 5. different fertilizers used (A: Rock phosphate; B: TSP; C: Urea)

Experimental set-up and fertilizers used: The experimental set-up used was a completely randomized Fisher block design with five replicates and two factors. The first factor consisted of the three legume modalities (cowpea, soybean and groundnut) and the second factor was fertilization at five (05) levels (F0, F1, F2, F3 and F4). The combination of rock phosphate, urea and triple superphosphate (TSP) fertilizers resulted in the following types of fertilization:

- F0 (RP0): Urea (14Kg N/ha)
- F1 (RP100): Urea (14Kg N/ha) +RP (100 Kg/ha)
- F2 (RP200): Urea (14Kg N/ha) + RP (200 Kg/ha)
- F3 (RP400): Urea (14Kg N/ha) + RP (400 Kg/ha)
- F4 (TSP): Urea (14Kg N/ha) + TSP (23Kg/ha)

Conducting the trial: Sowing was carried out on June 16, 2022 after labeling, with two 4.4m rows sown in each elementary plot, with a 40cm spacing between rows and bunches, including three (03) seeds per bunch, for a total of 24 bunches at a rate of 12 bunches per row.

Maintenance operations

- Weeding was carried out every week for ten weeks;
- Fertilizers were applied according to doses (RP0, RP100, RP200, RP400 and TSP) two weeks after sowing (15 JAS) per micro-dose to each elementary plot.

Data collection

- Number of plants emerged: This is obtained by counting the number of plants emerged per elementary plot;
- 50% flowering date: this is the period between sowing and the date when 50% of the plants have flowered on an elementary plot;
- Seed weight/elemental plot: This consisted in threshing the pods of each elementary plot separately and weighing the seeds using an electronic balance;
- 100-seed weight: This operation involved counting 100 seeds per elementary plot and weighing them using an electronic balance;
- Grain yield in kg/ha: This was calculated on the basis of seed weight in relation to the surface area of the elementary plot. To do this, the seed weight was multiplied by 10000m^2 which corresponds to one hectare (01ha), then divided by the area of the two lines of the elementary plot in m^2.

$$\text{Seed yield (Kg/ha)} = \frac{\text{(seed weight)}}{\text{(area of elementary plot)}} x10000$$

Data analysis: Data entry and graphing were carried out using Excel 2016. An analysis of variance (ANOVA) was performed using XLSTAT 2016 software according to the legume and fertilization factors. Means were compared using the Student Newman Keuls test at the 5% threshold.

RESULTS

Cycle-related parameters as a function of the three species and fertilization: The results of the analysis of variance on the various cycle-related parameters are presented in Table III. There was a highly significant difference (P=0.004) between varieties for the number of plants harvested; a very highly significant difference (P=0.000) for the parameters number of plants emerged and 50% flowering date. For the number of plants emerged, peanut and soybean showed the best performance, with a high average of 23.64±0.19plants and 23.64±0.15plants respectively. For the 50% flowering date, peanut and soybean took less time to reach 50% flowering, with an average of 42JAS, compared with soybean at 55.32±0.33JAS. In terms of the number of plants harvested,

Table 1. Some agronomic characteristics of the varieties used

Species	Variety	Origin	**cycle (days)**	Stem habit	Plant growth	Grain color	yield (t/ha)	Isohyet (mm)
Cowpea	Melakh	Senegal	52-61	Semi-rampant	Undetermined	White-cream	1	300-400
Soybeans	G196	Senegal	100-105	Erect	Undetermined	Yellow	2 à 3	750-1000
Groundnut	Te3	Burkina Faso	90	Erect	Undetermined	almon pink with flatErect	1,5 à 2	500-700

Source: CEDAO-UEMOA-CILSS regional catalog of plant species and varieties (2016).

Table 2. Different treatments depending on the two factors

Species	**Fertilization**	**Treatments**	**Treatment code**
Groundnut	RP0 (F0)	Arachide-RP0	Arach-RP0
Groundnut	RP100 (F1)	Arachide -RP100	Arach -RP100
Groundnut	RP200 (F2)	Arachide -RP200	Arach -RP200
Groundnut	RP400 (F3)	Arachide -RP400	Arach-RP400
Groundnut	TSP (F4)	Arachide -TSP	Arach –TSP
Cowpea	RP0 (F0)	Niébé- RP0	Niébé- RP0
Cowpea	RP100 (F1)	Niébé-RP100	Niébé-RP100
Cowpea	RP200 (F2)	Niébé-RP200	Niébé-RP200
Cowpea	RP400 (F3)	Niébé-RP400	Niébé-RP400
Cowpea	TSP (F4)	Niébé-TSP	Niébé-TSP
Soybeans	RP0 (F0)	Soja-RP0	Soja-RP0
Soybeans	RP100 (F1)	Soja-RP200	Soja-RP200
Soybeans	RP200 (F2)	Soja-RP400	Soja-RP400
Soybeans	RP400 (F3)	Soja-RP400	Soja-RP400
Soybeans	TSP (F4)	Soja-TSP	Soja-TSP

Table 3. ANOVA results for parameters related to species cycles according to variety and fertilization

Variables / Factors		**NPL**	**50% FL(JAS)**	**NPR**
species	Groundnut	23,64±0,19[a]	42±0,00[b]	21,24±0,23[a]
	Soybeans	23,64±0,15[a]	55,32±0,33[a]	21,6±0,15[a]
	Cowpea	22,32±0,34[b]	42,08±0,05[b]	20,44±0,32[b]
	Probability(P)	0,000	0,000	0,004
	Significance	Oui	Oui	Oui
Fertilizations	**RP0**	23,2±0,32[a]	46,46±1,69[a]	21±0,33[a]
	RP100	22,6±0,49[a]	46,53±1,68[a]	20,53±0,41[a]
	RP200	23,66±0,18[a]	46,46±1,69[a]	21,46±0,25[a]
	RP400	22,93±0,44[a]	46,6±1,74[a]	20,93±0,43[a]
	TSP	23,6±0,13[a]	46,26±1,62[a]	21,53±0,13[a]
	Probability(P)	0,163	1,000	0,200
	Significance	Non	Non	Non
species*fertilizations	**Probability(P)**	0,001	0,000	0,013
	Significance	yes	yes	yes

NB: Means in the same column followed by different letters are significantly different at p<0.05; **Legend**: NPL: Number of plants emerged, 50%FL: 50% Flowering, DAS: Days After Sowing, NPR: Number of plants harvested.

Tableau 4. Average values of the interaction between species and fertilization

Treatment	NPL	50%FL	NPR
C0W-TSP	23,2±0,2[a]	42±0,00[b]	21,2±0,2[a]
COW-RP0	23±0,63[a]	42±0,00[b]	21±0,63[a]
COW-RP100	20,4±0,6[b]	42,2±0,2[b]	18,8±0,48[b]
COW-RP200	23±0,44[a]	42±0,00[b]	21±0,44[a]
COW-RP400	22±1,09[a]	42,2±0,2[b]	20,2±1,11[ab]
GRO-RP0	23±0,77[a]	42±0,00[b]	20,4±0,74[a]
GRO-RP100	24±0,00[a]	42±0,00[b]	21,6±0,24[a]
GRO-RP200	24±0,00[a]	42±0,00[b]	21,4±0,6[a]
GRO-RP400	23,4±0,6[a]	42±0,00[b]	21,2±0,58[a]
GRO-TSP	23,8±0,2[a]	42±0,00[b]	21,6±0,24[a]
SOY-RP0	23,6±0,24[a]	55,4±0,6[a]	21,6±0,24[ab]
SOY-RP100	23,4±0,6[a]	55,4±0,6[a]	21,2±0,58[a]
SOY-RP200	24±0,00[a]	55,4±0,6[a]	22±0,00[a]
SOY-RP400	23,4±0,4[a]	55,6±128[a]	21,4±0,4[a]
SOY-TSP	23,8±0,2[a]	54,8±0,73[a]	21,8±0,2[a]
Probability(P)	0,000	0,000	0,013
Significance	yes	yes	yes

NB: Means in the same column followed by different letters are significantly different at p<0.05. Legend: COW: Cowpea, GRO: Peanut, SOY: Soybean, NPL: Number of plants emerged, FL: Flowering, NPR: Number of plants harvested.

Table 5. Average yield values and components

Factors \ Variables		Pds_gr(g)	Pds_100gr(g)	Rdt_gr (kg/ha)
Species	**Groundnut**	598,19	14,39	6485,23
	Soybean	289,67	10,06	2738,64
	Cowpea	383,62	29,38	3031,82
	Probability(P)	0,0001	0,0001	0,0001
	Significance	yes	yes	yes
Fertilizations	**RP0**	401,39	17,78	3544,89
	RP100	395,93	18,03	6472,16
	RP200	457,43	17,85	6485,23
	RP400	446,16	17,85	5235,23
	TSP	418,22	18,19	3031,82
	Probability(P)	0,867	1,000	0,867
	Significance	yes	yes	yes
Species*fertilization	**Probability(P)**	0,0001	0,0001	0,0001
	Significance	yes	yes	yes

Legend: Pds : weight, gr : grain, Rdt :yield

groundnuts and soybeans performed best, with an average of 21 plants harvested, compared with cowpeas with an average of 20.44±0.32 plants harvested. As for fertilization, no significant difference was observed on cycle-related parameters. With regard to interaction, a significant difference (P=0.013) was observed for the number of plants harvested (NPR); a highly significant difference (P=0.001) for the number of plants lifted (NPL) and a very highly significant difference (P=0.000) for the date of 50% flowering (50%FL). For emergence, cowpea recorded the best performance with the TSP fertilizer with an average of 23.2±0.2plants; groundnut recorded the highest average value ((24±0.00plants) with the RP100 and RP200 fertilizers; the best performance of soybean was recorded with the RP200 fertilizer (24±0.00plants). Cowpea took less time to reach 50% flowering (42±0.00 JAS) with TSP, RP0 and RP200 fertilizers; Groundnuts took less time (42±0.00JAS) with fertilizers RP0, RP100, RP200, RP400 and TSP; on the other hand, soybeans took less time to reach 50% flowering (55.4±0.6JAS) with fertilizers RP0, RP100 and RP200. For the number of plants harvested (NPR), cowpea had the highest average value (21.2±0.2plants) with TSP fertilizer; groundnut recorded the highest average value (21.6±0.24plants) with TSP and RP100 fertilizers; soybean had the best performance (21.8±0.20plants) with TSP fertilizer.

Yield parameters and their components as a function of the two factors and the interaction: Analysis of variance (5% threshold) on seed weight variation (figure 3) showed a highly significant difference (P=0.0001) depending on the interaction. Cowpea performed well with all fertilizations. The best performance was observed with RP400 fertilizer at 670.78 g. Groundnuts performed well with TSP fertilizer (434.778g); soybeans performed best with RP200 (341.18g).

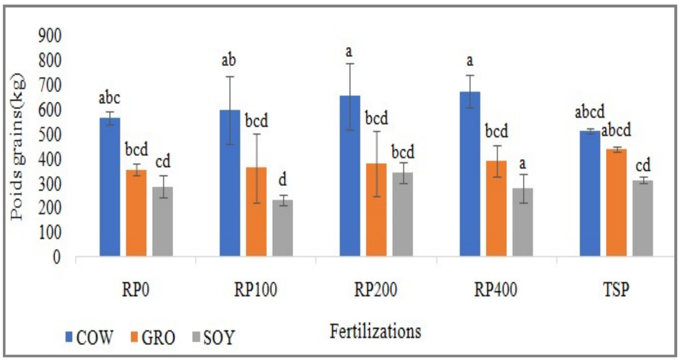

Figure 3. variation in seed weight as a function of interaction (Legend: COW: Cowpea, GRO: Peanut, SOY: Soybean)

Figure 4 shows the results of the analysis of variance (at the 5% threshold) of the weight of 100 seeds as a function of interaction. These results showed a highly significant difference (P=0.0001), meaning that there was no significant difference between each species and the different fertilizations. However, the highest mean values were obtained with the TSP fertilizer for groundnuts (30.06g); the RP100 fertilizer for cowpeas (14.66g) and the RP0 fertilizer for soybeans (10.54g).

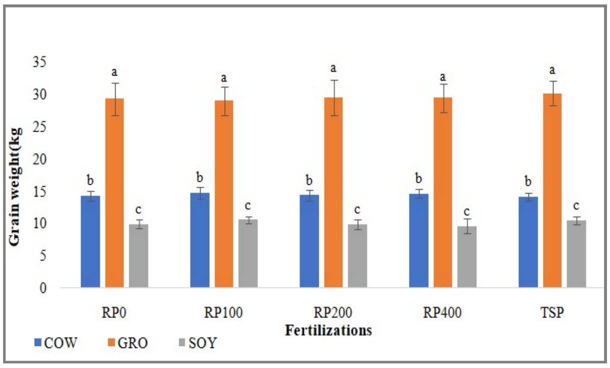

Figure 4. shows the results of the analysis of variance (at the 5% threshold) of the weight of 100 seeds as a function of interaction

These results showed a very highly significant difference (P=0.0001). Thus, there was no significant difference between each species and the different fertilizations. However, the highest mean values were obtained with the TSP fertilizer for groundnut (30.06g); the RP100 fertilizer for cowpea (14.66g) and the RP0 fertilizer for soybean (10.54g).

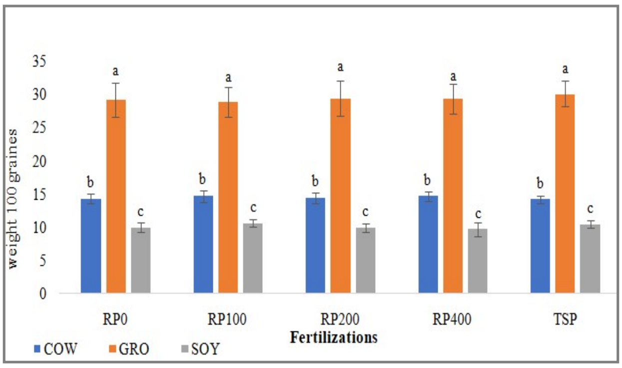

Figure 4: variation in weight of 100 seeds as a function of interaction

The results of the analysis of variance on seed yield as a function of interaction are shown in figure 5. These results show a significant difference (P=0.0001). There was no significant difference between each species and the different fertilizations. However, cowpeas performed best with RP400 (3811.25 kg/ha), groundnuts with TSP (2470.34 kg/ha) and soybeans with RP200 (1938.52)kg/ha).

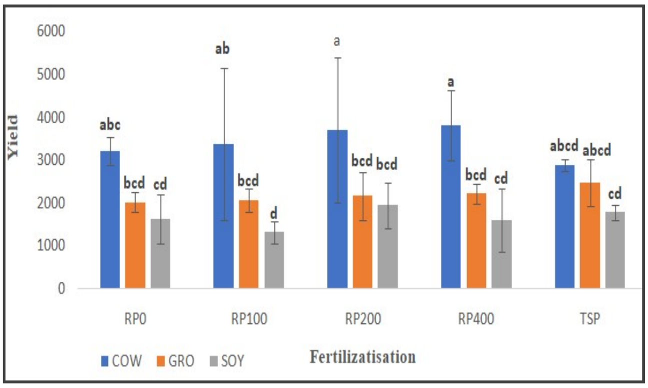

Figure 5. Yield variation as a function of interaction

DISCUSSION

The results of the analysis of variance (at the 5% threshold) showed a significant difference for the parameters number of plants lifted, 50%flowering and number of plants harvested, depending on the species. This indicates the existence of variability between the different species. The average number of plants emerged could be explained by seed quality, humidity, temperature and light, all of which are necessary conditions for germination. These results are similar to those of (Dullooand *et al.*, 2017) who reports that the emergence rate of a given crop or variety depends on several factors, namely seed quality, fertilization and cultivation practices. The variation observed for the 50% flowering date is due to the genotypic variation of the different species evaluated. These results are in line with those of Pandey et al, (2006) who showed that the difference in flowering day could be due to varietal character, sowing time and growing environment. As for the number of plants harvested, this significant difference could be explained by climatic factors and diseases that negatively influence species development. Under the effect of fertilization, the significant variation observed would be due to several factors that condition the efficiency of the nutrients provided by the different fertilizers. As a result, fertilization improves the chemical and physical fertility of the soil. In this study, fertilization provided nitrogen through urea, while Rock phosphate released phosphorus, the two main mineral elements limiting soil productivity in Burkina Faso (Traore *and* Toé, 2008). This study shows that the combination of Rock phosphate and TSP with urea provides a good stimulation of the parameters linked to the species cycle; this is in line with the work of (Sedogo *et al.* 1983; Lompo, 1993) which shows that the direct application of rock phosphate has a beneficial effect on most plants grown in acid soils. Indeed, because of the legume's inability to fix nitrogen early in its cycle, a minimum of nitrogen fertilizer is needed in poor soils to improve yields (Bado, 2002). However, a nitrogen fertilizer application of 14Kg urea/ha (control) was applied to each elementary plot. The results for the parameter related to yield components as a function of fertilization show a more favorable use of rock phosphate with the fertilizer RP400 for cowpea, TSP for groundnut and RP200 for soybean for the seed weight parameter. This means that RP400, TSP and RP200 have considerable potential for improving seed weight yields in cowpea, groundnut and soybean respectively. As for the 100-seed weight parameter, the most favorable use of Rock phosphate was noted with the TSP treatment for groundnuts and RP100 for soybeans and cowpeas. This difference in seed weight could be based on the time taken to accumulate reserves in the seeds due to fertilization or the genetic composition of the different species, as well as the climatic adaptation factor. This result also supports the work carried out by Khan *et al,* (2010) who found a highly significant variation for 100-seed weight in 24 cowpea genotypes. As for seed yield, the most favorable use of Rock phosphate was with the TSP fertilizer for groundnuts, RP400 for cowpeas and RP200 for soybeans. This difference in seed weight could be based on the time taken to accumulate reserves in the seeds due to fertilization or the genetic composition of the different species, and also the climatic adaptation factor. This result also supports the work carried out by Khan *et al,* (2010) who found a highly significant variation for 100-seed weight in 24 cowpea genotypes. As for seed yield, the most favorable use of Rock phosphate was noted with the TSP fertilizer for groundnuts, RP400 for cowpeas and RP200 for soybeans. All these fertilizers applied to each species improved yield components, which could be explained by the fact that the combination of urea + Rock Phosphate and urea + TSP increases soil nutrient availability and therefore positively influences crop yield. Our results are similar to those of Lompo, (1995) who recommends the use of Rock phosphate at 400kg/ha as a basal fertilizer and 100kg/ha per year for the production of millet, maize, sorghum, cotton, groundnuts and soybeans. In fact, the effectiveness of Rock phosphate depends on cultural practices such as ploughing, the addition of organic matter and techniques for soil and water conservation and soil defense and restoration. These results on cowpea production contradict the work of Dullooand *et al.*, 2017who show that in phosphorus-poor soils, an application of 40kg P2O5/ha increases cowpea seed yields. This difference can be explained by the low solubility of Rock phosphate in the first year of cultivation. In the same vein, Maltas *et al,* (2012) indicate that when nitrogen is non-limiting, organic fertilizers have contrasting effects on crop yields; on the other hand, when it is limiting, organic fertilizers all have a positive tail effect on crop yields.

CONCLUSION

This study highlighted the influence of Rock phosphate fertilization on the cycle parameters and yield of legume species on a lithosol located at Ralo in the commune of POA. The results of the present study showed that the combined application of Rock phosphate fertilization induced a significant difference (at the 5% threshold) in the cycle-related parameters of the species. However, the highest average values in terms of seed weight, 100 seeds and grain yield were obtained with RP400, RP100 and RP400 for cowpea, and RP200, RP100 and RP200 for soybean. Groundnut yields were higher with TSP than with RP0 (control).

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