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# Effect of *Alsil* fertilizer on the productivity of groundnut and its residual effects on succeeding Pearl millet under growing conditions in the northern groundnut basin of Senegal

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**ABSTRACT**

*Objective:* In Senegal, low soil fertility is one of the major constraints on crop productivity, particularly for legumes and cereals. For optimum long-term productivity, appropriate management of soil resources is required. It is in this context that this study was carried out to investigate the direct effects of *Alsil* fertilizer on the productivity of groundnut and its residual effects on succeeding Pearl millet.

*Methodology and results*: The study was carried out during the 2021 rainy season and the 2022 off-season at the CNRA in Bambey using a randomised complete block design with three replicates. The results showed that direct application of *Alsil* and its residual-effect significantly improved groundnut and Pearl millet yields. For groundnut, direct application of *Alsil* produced the highest dry pod and haulm yields (2369 kg.ha-$^{1}$ and 3780 kg.ha-$^{1}$ respectively). Yield increases were 509 kg.ha-$^{1}$ and 302 kg.ha-$^{1}$ respectively compared with the recommended mineral fertilizer (N-P-K (6%, 20%, 10%). For Pearl millet, the residual effect of *Alsil* fertilizer recorded the highest grain (1136 kg.ha-$^{1}$) and straw (9561 kg.ha-$^{1}$) yields. The yield increases resulting from the residual effect of Alsil, compared with the application of the recommended mineral fertilizer (NPK 15-10-10), were 330 kg ha$^{-1}$ for grain and 2,985 kg ha$^{-1}$ for straw.

*Conclusion and application of results:* The results showed a positive and significant effect of the application of the Alsil fertilizer on the yields of groundnut and millet, compared with the recommended mineral fertilization and compost. The effect of the Alsil fertilizer was more pronounced on pod production than on haulm production in groundnut.. This study has applications for sustainable land management and improving groundnut and Pearl millet yields. *Alsil* could not only improve soil fertility in the Senegalese groundnut basin, but also reduce the excessive use of chemical fertilisers, which is harmful to the environment.

**Keywords :** Peanut, Pearl millet, *Alsil* fertiliser, yield, Senegal.

## INTRODUCTION

Groundnut (*Arachis hypogaea* L., Fabaceae) is a leguminous plant native to Latin America (Kouadio, 2007). It is widely cultivated throughout the intertropical zone and constitutes an important source of nutrition and income. It ranks as the sixth most important oilseed crop in the world (FAO, 2003). China and India are the leading producers, supplying over 60% of production. Africa provides around 25% of production, with Nigeria, Senegal and Sudan in particular (Kouadio, 2007). Senegal's production currently lags far behind China (3.6 million hectares and 6 million tonnes produced annually), India (over 8 million hectares and around 5.6 million tonnes per year), the United States, Nigeria, Argentina and Indonesia (between 1 million and 1.5 million tonnes per year). What's more, Senegalese groundnut products now account for just 4% of exports, a far cry from the record 80% of exports that groundnuts represented at independence (Ndéné, 2011). Nevertheless, groundnuts remain Senegal's leading crop and legume and continue to play a vital role in the rural economy. Groundnuts provide essential nutrients, particularly protein, and are also rich in fibre, minerals and vitamins. (Annerose, 1990; FAO, 2003). In rotation, legumes increase the nitrogen available in the soil and constitute a large, diverse and agriculturally important family in the plant kingdom (Heywood, 1971). The benefits of legumes in cereal cropping systems are well established. Legumes have a favourable impact on soil fertility and help to increase the yield of subsequent crops (Jain *et al.,* 2005). Legumes are able to fix atmospheric nitrogen and transform it into plant-available forms that can be utilized for growth (Allen & Allen, 1981). Pearl millet, Pennisetum glaucum, is a staple food and a vital source of energy for millions of people living in semi-arid tropical areas (Hafida, 2016). Ranked as the 7th most important cereal in the world, global Pearl millet production is estimated at 28.4 million tonnes over an area of 31.7 million hectares (FAOSTAT, 2021). In Senegal, production is 1,144,855 tonnes from 1,023,065 ha, with an average yield of 1,119 kg.ha-$^{1}$ (ANSD, 2022). However, production is hampered by several factors, including irregular rainfall distribution, exacerbated by climate change, various crop diseases and pests, and above all low soil fertility and sandy soils (Seguin and Soussana, 2008). So, one of the actions being taken in Senegal is to improve soil fertility. Nutrient management in crop succession is an important step in the agronomic practices that are responsible for the long-term sustainable production of these crops. Nutrient requirements vary according to the different crops in the system and, if studied systematically, can help to regulate the nutrient requirements of subsequent crops in terms of fertilizer savings and changes in soil fertility. Fertilization is an essential factor in increasing crop production. However, the continued use of chemical fertilizers has adverse effects on the soil, leading to reduced productivity, low nutrient recovery efficiency, increased production costs especially with the high cost of chemical fertilizers and environmental pollution (Sarkar *et al.,* 1997). It is advisable to reduce the use of chemical fertilizers and increase the use of organic fertilizers, as this will considerably control pollution of the global environment. The application of organic fertilizers can also improve the availability of indigenous nutrients in the soil and the effectiveness of applied fertilizers (Sawrup, 2010), stimulate the proliferation of various groups of soil micro-organisms and play an important role in maintaining the ecological balance of the rhizosphere (Chowdhury *et al.,* 2011). As groundnut are legumes, they leave a lot of residual fertility that the following crop can benefit from. Thus, the incorporation of natural mineral fertilizer such as *Alsil* is undertaken in this study. *Alsil* belongs to a family of hydro-retaining products, biological activators and growth enhancers. Its use in agriculture is a method of biological soil fertilisation. It stimulates microbiological activity in the soil, has a high adsorption capacity for all the major plant nutrients, improves soil structure, combats drought thanks to its ability to retain water and gas due to its high porosity, and mineralises slowly in the soil. It is also a low-cost and easily accessible fertilizer. The groundnut-Pearl millet rotation is the most common in Senegal, but its potential has been little studied without fertilizer applied to the cereal. The aim of this study was therefore to investigate the direct effects of *Alsil* fertilizer on the productivity of groundnut and its residual effects on succeeding Pearl millet under growing conditions in the northern groundnut basin of Senegal.

## MATERIALS AND METHODS

**Experimental site:** The trial was conducted during the 2021 rainy season and the 2022 off-season at the CNRA Bambey station. The Bambey station is characterized by a Sahelian-type climate with a long dry season (8–9 months) and a short rainy season (3–4 months). Rainfall shows strong interannual variability. The dominant soils are sandy and characterized by a very low water-holding capacity of 80 to 100 mm $m^{-1}$ (Vachaud *et al.,* 1978; Hamon, 1980). The characteristics of the soil analysis where the trial was implanted are presented in Table 1.

**Table 1:** Summary of soil analysis results before sowing the trial.

| Horizon | | Clay | Silt | Sand | pH | OM | T/C | C/N |
|---|---|---|---|---|---|---|---|---|
| | | % | | | 1/2,5 | % | | |
| 0-20 cm | Replicate 1 | 4.49 | 2.22 | 93.3 | 6.9 | 0.58 | 0.334 | 12.81 |
| | Replicate 2 | 4.62 | 2.34 | 93 | 7.06 | 0.64 | 0.369 | 19.7 |
| | Replicate 3 | 4.07 | 3.21 | 92.7 | 7.88 | 0.65 | 0.379 | 24.72 |
| 20-40 cm | Replicate 1 | 8.73 | 2.3 | 89 | 6.61 | 0.43 | 0.241 | 12.13 |
| | Replicate 2 | 9.21 | 2.11 | 88.7 | 6.68 | 0.5 | 0.29 | 6.82 |
| | Replicate 3 | 9.4 | 2 | 88.6 | 7.47 | 0.47 | 0.27 | 14.02 |

OM : Organic matter ; T/C: Total carbon; C/N: carbon-nitrogen ratio

**Plant material and fertilizers used:** The groundnut variety used was Boulkhouss, also known as “Hâtive de Séfa”. It is a confectionery variety, susceptible to cercosporiosis and drought, with low dormancy, excellent pod grouping and good fodder quality of the haulm. It has an upright growth habit, a light pink seed coat and matures in 90 days after sowing, giving a yield of 1.5 t. ha-[1]. The mineral fertilizers used were N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca), N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca), N-P-K fertilizer (15%N, 10%P, 10%K) and N-P-K fertilizer (6%N, 20%P, 10%K). Compost and *Alsil* were used for organic fertilizers. *Alsil* is obtained as a result of the sieving and transformation of magma formed over billions of years in the deep layers of the earth. The *Alsil* used in this study was supplied by AGRIBEL Senegal.

**Trial management:** In the rainy season of 2021, the soil was ploughed and harrowed with a tractor, followed by a pass with a rake to break up the clods of earth to create a seedbed. In the 2022 off-season, tillage consisted solely of scraping the soil with a horse-drawn Sine hoe to keep the plots intact. he seeds were treated with the fungicide–insecticide Granox, which contains a combination of captafol-benomyl and carbofuran. Groundnut and Pearl millet were sown in the rainy season after good rainfall on 06 August 2021 and in off-season on 02 April 2022. The seedlings were sown manually, at a rate of two seeds per hill for groundnut and 10 seeds for Pearl millet, at a depth of 3 to 4 cm. For groundnut, the spacing between rows was 0.5 m and between hills 0.15 m. For Pearl millet, the spacing between rows and on the row was 0.90 m. Groundnut were thinned to one plant per hill and Pearl millet to three plants per hill in wet conditions about 15 days after sowing. Organo-mineral fertilization was applied according to the test treatments as a basic manure just after sowing. In the case of Pearl millet, two urea applications (46% N) were done at a rate of 50 kg.ha-$^{1}$ per application, just after thinning for the first, then on stem elongation for the second. *Alsil* was only applied initially in the groundnut trial. Pearl millet benefited from the after-effects of *Alsil* fertilizer. Weeding-hoeing and pesticide treatments were applied as required to minimise the impact of crop pests. Anti-erosion bunds were built all around the trials to limit run-off.

**Experimental design and variables measured**: A randomized complete block design with three replicates was used. The factor studied was organo-mineral fertilisation at five levels. For groundnut in the 2021 rainy season, the treatments were: F0 (absolute control: 0 kg.ha-$^{1}$: no input), F1 (1500 kg.ha-$^{1}$ *Alsil*), F2 (150 kg.ha-$^{1}$ N-P-K fertilizer (6%N, 20%P, 10%K)), F3 (150 Kg. ha-$^{1}$ N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca)) and F4 (1500 Kg. ha-$^{1}$ compost). In the 2022 off-season, the treatments for Pearl millet were: F0 (absolute control: 0 kg.ha-$^{1}$: no input), F1 (residual *Alsil* applied in 2021 rainy season), F2 (150 kg.ha-$^{1}$ N-P-K fertilizer (15%N, 10%P, 10%K)), F3 (150 kg. ha-$^{1}$ N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca)) and F4 (1500 kg.ha-$^{1}$compost). The 2022 trial was sown in the same location as the 2021 rainy season trial with the same unit plots to study the residual effect of the *Alsil* fertilizer. The surface area of the unit plots was 24 m² (8 rows of 6 m in length). A total of 15-unit plots were set up in the trial. To assess yields, hills from the entire unit plot were harvested, eliminating two border lines on each side and three hills at the end of each line. Data were collected and analysed at two levels: dry pod and dry haulm yield for groundnut and grain yield and straw for Pearl millet in kg.ha-$^{1}$. Soil samples were collected from the 0–20 cm and 20–40 cm depths for physical and chemical characterization of the soil prior to the establishment of the trial. Statistical data analysis: The yield data collected were carried out to an analysis of variance and the means were compared using the least significant difference (LSD) method at 5% probability if a significant difference between treatments was noted. The R software, version R-3.6 was used.

## RESULTS

**Direct effects of *Alsil* fertilizer on dry pod and haulm groundnut yields:** The analysis of variance carried out on dry pod yield revealed a significant difference between the treatments studied at the 5% level. Yields varied from 1771 kg.ha-$^{1}$ to 2369 kg.ha-$^{1}$ (Figure 1). The plots fertilised with *Alsil* fertilizer (F1) gave the best pod yields compared with those fertilised with the other treatments (Figure 1). The added values for F1 were +610 kg.ha-$^{1}$, +509 kg.ha-$^{1}$, +472 kg.ha-$^{1}$and +598 kg.ha-$^{1}$compared with F0 (absolute control), F2 (N-P-K fertilizer (6%N, 20%P, 10%K)), F3 (N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca)) and F4 (Compost) respectively. For dry haulm, the results of the analysis of variance carried out on hull yield did not show a significant difference between treatments at the 5% threshold. Yields ranged from 2840 kg.ha-$^{1}$to 3780 kg.ha-$^{1}$ (Figure 2). The plots fertilised with *Alsil* (F1) recorded the best dry haulm yields compared with those fertilised with other types of fertilizers (Figure 2). The added value generated by F1 was +716 kg.ha-[1], +302 kg.ha-[1], +14 kg.ha-[1]and +940 kg.ha-[1] compared with F0 (absolute control), F2 (N-P-K fertilizer (6%N, 20%P, 10%K)), F3 (N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca)) and F4 (Compost) respectively.

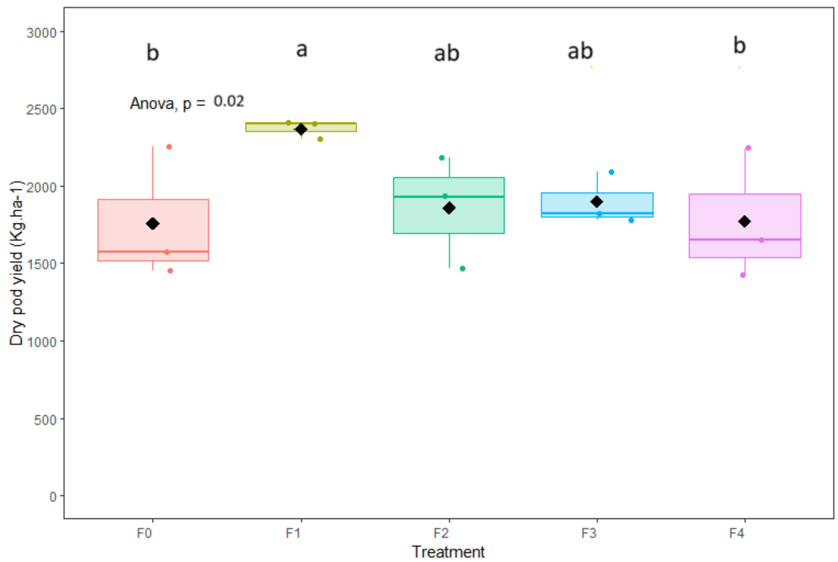


**Figure 1:** Dry pod yield (Kg.ha-[1]) according to the treatments studied**.**
F0: Absolute control; F1: *Alsil*; F2: N-P-K fertilizer (6%N, 20%P, 10%K); F3: N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca); F4: Compost. Means followed by the same letter are not significantly different at the 5% level according to the LSD test. the black dots represent the average and the other dots the values observed during the experiment.

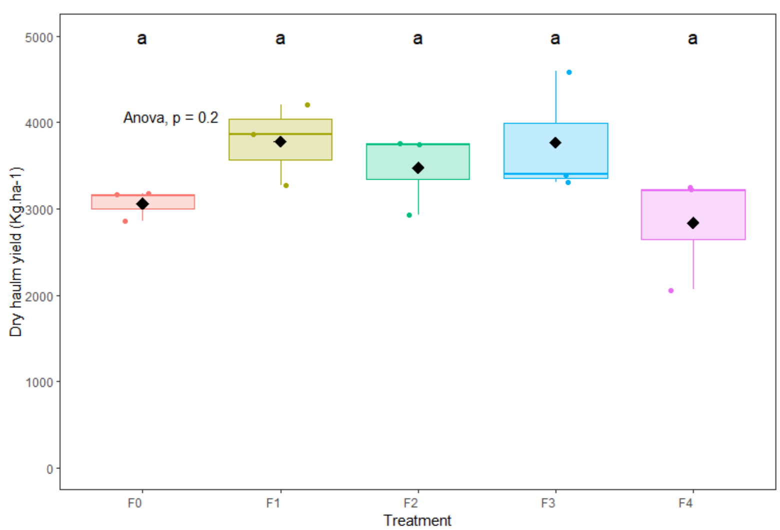


**Figure 2 :** Dry haulm yield (kg.ha-[1]) according to the treatments studied.
F0: Absolute control; F1: *Alsil*; F2: N-P-K fertilizer (6%N, 20%P, 10%K); F3: N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca); F4: Compost. Means followed by the same letter are not significantly different at the 5% level according to the LSD test. the black dots represent the average and the other dots the values observed during the experiment.

**Residuals effects of *Alsil* fertilizer on grain and straw Pearl millet yields:** The results of the analysis of variance showed significant differences between treatments in grain yield at the 5% level. Yields varied between 1136 kg.ha-1 and 357 kg.ha-1. Treatment F1 (residual effect of *Alsil*) recorded the highest yield with a value of 1136 kg.ha-1 (Figure 3). The lowest value was obtained by the absolute control (357 kg.ha-1). The yield increases obtained with residual *Alsil* were +779 kg.ha-1, +330 kg.ha-1, +410 kg.ha-1 and +549 kg.ha-1 compared with the absolute control (F0), N-P-K fertilizer (15%N, 10%P, 10%K) (F2), N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca) (F3) and compost (F4), respectively. Straw yield was also significantly influenced by the treatments applied. Yields varied between 9561 kg.ha-1 and 3955 kg.ha-1. The residual effect of *Alsil* produced the highest yield with a value of 9561 kg.ha-1 (Figure 4). The lowest value was obtained with the absolute control (3955 kg.ha-1).The yield increases were respectively +5606 kg.ha-1, +2985 kg.ha-1, +1999 kg.ha-1, +4808 kg.ha-1 compared with the absolute control, N-P-K fertilizer (15%N, 10%P, 10%K), N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca) and compost.

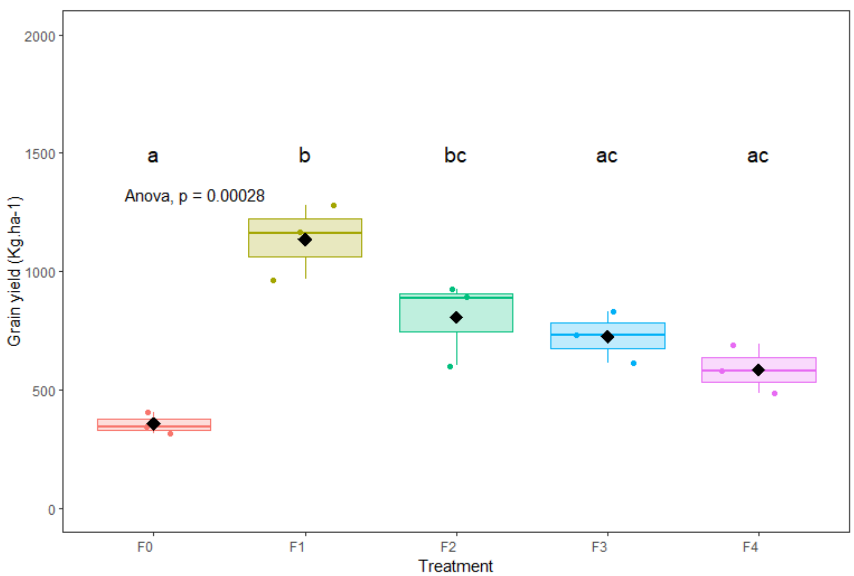


**Figure 3 :** Grain yield (Kg.ha-1) according to the treatments studied**.**
F0: Absolute control; F1: *Alsil*; F2: N-P-K fertilizer (15%N, 10%P, 10%K); F3: blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca); F4: Compost. Means followed by the same letter are not significantly different at the 5% level according to the LSD test. the black dots represent the average and the other dots the values observed during the experiment.

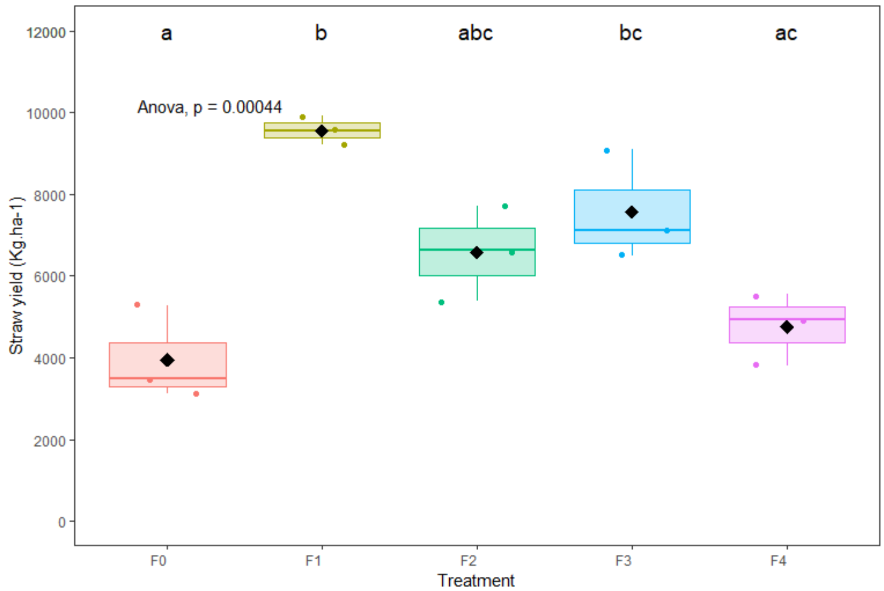


**Figure 4 :** Straw yield (Kg.ha-[1]) according to the treatments studied.
F0: Absolute control; F1: *Alsil*; F2: N-P-K fertilizer (15%N, 10%P, 10%K); F3: blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca); F4: Compost. Means followed by the same letter are not significantly different at the 5% level according to the LSD test. the black dots represent the average and the other dots the values observed during the experiment.

## DISCUSSION

The results of the study on the direct effects of *Alsil* fertilizer on groundnuts showed that this fertilizer performed better than inorganic fertilizers and compost in terms of pod and haulm yield. For pods, *Alsil* performed significantly better than the other treatments. The gains were + 610 kg.ha-[1], + 509 kg.ha-[1], + 472 kg.ha-[1] and + 598 kg.ha-[1] respectively compared with F0 (absolute control), F2 (N-P-K fertilizer (6%N, 20%P, 10%K)), F3 (N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca)) and F4 (compost).These results could be explained by the very nature of *Alsil* in improving plant nutrition. *Alsil* belongs to a family of hydro-retaining products, biological activators and growth enhancers. Its use in agriculture is a component of the organic soil fertilisation method. It stimulates microbiological activity in the soil, has a high adsorption capacity for all the major plant nutrients, improves soil structure, combats drought thanks to its ability to retain water and gas due to its high porosity, and mineralises slowly in the soil. It is also an inexpensive and readily available fertilizer. These results agree with those of Mohapatra and Dixit (2010), who showed that the application of organic fertilizer increased groundnut yield compared with applications of complex inorganic fertilizers. For dry haulm, no significant differences were observed between *Alsil* and the other types of fertilizers (inorganic and compost). However, in terms of yield, *Alsil* recorded higher arithmetic values than the other types of fertilizers (inorganic and compost): +716 kg.ha-[1], +302 kg.ha-[1], +14 kg.ha-[1] and +940 kg.ha-[1] respectively compared with F0 (absolute control), F2 (N-P-K fertilizer (6%N, 20%P, 10%K)), F3 (N-P-K-S-Ca blending fertilizer (6%N, 20%P, 10%K, 4%S, 4%Ca)) and F4 (compost). These results agree with those of Tiwari *et al.* (2002), who reported that groundnut yield was significantly higher with the application of organic fertilizer compared with the single application of 40 kg N/ha. The better overall performance of groundnut with the *Alsil* treatment may be because it stimulates soil microbiological activity, which allows high nitrogen fixation by groundnut through the symbiotic relationship with rhizobia (Dharma, 1996). This plays an important role in maintaining crop productivity and fertility in semi-arid lands (Desoky *et al.,* 2011). Similar results have also been reported by Purbajanti *et al.* (2019) and Kulkarnu *et al.* (2018) on groundnut. The results of the residual effects of the *Alsil* fertilizer on the Pearl millet crop showed grain yield increases of 218%, 41%, 56% and 93% compared with the application the absolute control (F0), the N-P-K fertilizer (15%N, 10%P, 10%K), the N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca) and compost respectively. Regarding straw production, yield increases were 142%, 45%, 26% and 101% respectively compared with the absolute control, N-P-K fertilizer (15%N, 10%P, 10%K), N-P-K-S-Ca blending fertilizer (15%N, 10%P, 10%K, 4%S, 4%Ca) and compost. These results could be explained by the fact that *Alsil* may have stimulated the activities of micro-organisms that made plant nutrients readily available to crops, thereby increasing Pearl millet yields. In addition, *Alsil* has a vast capacity to adsorb all the major plant nutrients, especially nitrogen, which is the mainstay of mineral fertilisation of cereals. Similar results were observed by Kumawat *et al.* (2018) who, by studying the residual effects of organic fertilizer derived from farmyard manure stimulating the activity of micro-organisms, showed that Pearl millet yield and starch had significantly increased. The superiority of the residual effects of natural organic fertilizers over complex inorganic fertilizers has been reported by Dhaliwal *et al.* (2023) on wheat and Srivatsava *et al.* (2015) on Pearl millet and wheat.

## CONCLUSION AND APPLICATION OF RESULTS

The results of the evaluation of the *Alsil* fertilizer on the productivity of groundnut and Pearl millet showed the very good response of groundnut and Pearl millet to the *Alsil* fertilizer compared with the recommended mineral fertilizer (N-P-K fertilizer (6%N, 20%P, 10%K)), the blended fertilizer enriched with Sulphur and Calcium (essential elements in the filling of groundnut pods) and compost. In groundnuts, this response is more pronounced in the pods than in the haulm. Direct application of *Alsil* increased groundnut dry pod yields by 40% compared with the recommended mineral fertilizer (N-P-K fertilizer (6%N, 20%P, 10%K)). On Pearl millet, the residual effect of *Alsil* resulted in an increase in grain yield of 41% compared with recommended mineral fertilizer (N-P-K fertilizer (15%N, 10%P, 10%K)) and 93% compared with compost. Alsil could therefore be an alternative to chemical fertilizers for sustainably increasing groundnut and Pearl millet yields in groundnut/Pearl millet cropping systems in the northern groundnut basin of Senegal.

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**Conflicts of interest**: The authors declare no conflict of interest.

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