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Practices and Systems Applied in Common Beans Farming in Burundi

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Abstract

Farming is a main job occupying a large part of the world wide population among which Burundians. Farming products are a main source of food system. Many techniques among which digitalization are being applied to tackle the growing need in food for the humanity while fertility is decreasing. This article is to analyze different practices developed or applied farming common beans in Burundian acid soil. We used a questionnaire administrated to a sample of 283 respondents, in which we used Kobocollect tools in data collection. Data analysis was helped by IBM SPPS 25 tools and Microsoft Office Excel. Results show that the system is dynamic for whether they use the combination or association of different seeds in a single crop, not even following expert councils. They cannot afford fertilizers' price while a large number of our respondents do not know dolomite meaning they do not use it. While a few use compost or manures from cattle, their harvest denotes a very low bean production that needs to be increased by different systems to think about population satisfaction in Beans instead of letting things this way.

Keywords

Beans, Farmer, Fertilizer, Dolomite Use, Production Increase, Pesticide, Farming System Agent

1. Introduction

Agricultural sustainability is a center of food thinkers for, currently, 42% of the world's population depends on agriculture for its livelihood, in the context of agriculture drives the economy of most developing countries (Aznar-Sánchez et al.,

2019) among which Burundi taking into consideration that soils are the source of 98.8% humans food with of our (Kopittke et al., 2019). However, earth or soil is experiencing degradation that decreases its ability to provide humans with food production through different environmental harm (Nijimbere et al., 2025; Sindayigaya, 2023a, 2023b).

To tackle such issues, different techniques are being tried among which home gardening practices (Lal, 2020) and fertilizers (Tudi et al., 2021) and agricultural machines (Pallathadka et al., 2023) used in the context of agricultural artificial intelligence (He et al., 2018). All these efforts are deployed targeting the achievement of worldwide humans' food self-sufficiency via sustainable intensification of agriculture (Beltran-Peña et al., 2020).

Besides, farmers are using pesticides which are becoming indispensable for the increase of agricultural production (Tudi et al., 2021). They have been utilizing them to control weeds and insects and harvests are the witness of their importance (Victor et al., 2023; Sindayigaya & Toyi, 2023a). This is applied while also applying the possibility for agriculture to be the source of its own performer in the sense farming waste become fertilizers and manure to increase land productivity as confirmed by FAO (Oluseun Adejumo et al., 2020; Duque-Acevedo et al., 2020; Nuhu et al., 2023).

The smart farming approach (Klerkx et al., 2019) implemented in agriculture implies the generation of digitalization in agriculture (Nasirahmadi & Hensel, 2022) that governs the future of digital agriculture and sustainable food systems policy (Lajoie-O'Malley et al., 2020). Even though the technical itinerary is not always well applied due to high cost of inputs and farming tools, inaccessibility of fertilizers and phytosanitary products, and lack of manpower (Yasser & Wanis, 2021), agriculture tries other techniques like sowing seeds and seedlings online and follow the advice of agricultural instructors (Faye et al., 2022) in the same way it is in Senegal.

In Burundi, the ministry in charge of farming and agriculture applied decentralized of the administration. This means it is effectively represented on the level of provinces, the level of communes till the hill farm monitors or instructors (Nyabenda & Sindayigaya, 2023).

The aim of this article is to analyze the way Burundian farming systems apply these techniques in the context of growing beans in the acid land of Burundi.

2. Methods and Methodology

This article is a result of a survey conducted by 4 interviewers with 283 respondents (chosen randomly) on the following dates:2023-04-24, 2023-04-26, 2023-05-16, 2023-05-17, 2023-05-18 2023-05-31, 2023-06-01, 2023-06-13, 2023-06-14, 2023-06-15, 2023-06-29 and 2023-07-04.

The survey was conducted in 15 sub-hills of 4 hills:

- 70 from Kizingoma hill in Makamba commune and province;
- 71 respondents from Mitakataka hill in Bubanza commune and province;
- 72 respondents from Mukonko hill in Nyabiraba commune and Bujumbura province;
- 70 respondents from Shanga hill in Buhiga commune and Karusi province.

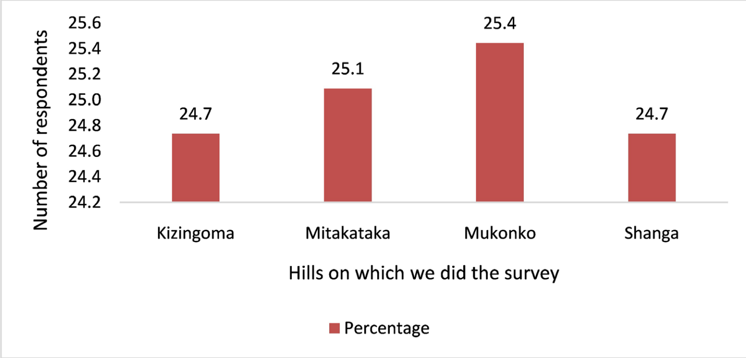

Figure 1. Hills origin of respondents.

Referring to gender, the target population of this article considers women 147 respondents representing 48.4% and 137 men 137 responding to our questionnaire, representing 51.6% (See Figure 1).

Over four-fifths of the respondents of our questionnaire, i.e. 240 out of 283 respondents (representing 84.8%) are from households whose chiefs are male, 41 respondents (it means 14.5%) from families whose chiefs are female, and 2 respondents (0.7%) from orphan children.

While a very large number of our respondents, in number of 173 out of 283 respondents (representing 61.1%) were chiefs of their households, 113 respondents (meaning 38.9%) were only members of their households.

Data collection was used with Kobokollect tool. IBM SPSS 25 software (Statistical Package for Social Sciences IBM 25) and Microsoft Office Excel were used to enter data on a model beforehand. Zotero software was used for references and biography throughout the text.

3. Main Results Analysis

In this part, we present the results in figures and tables below.

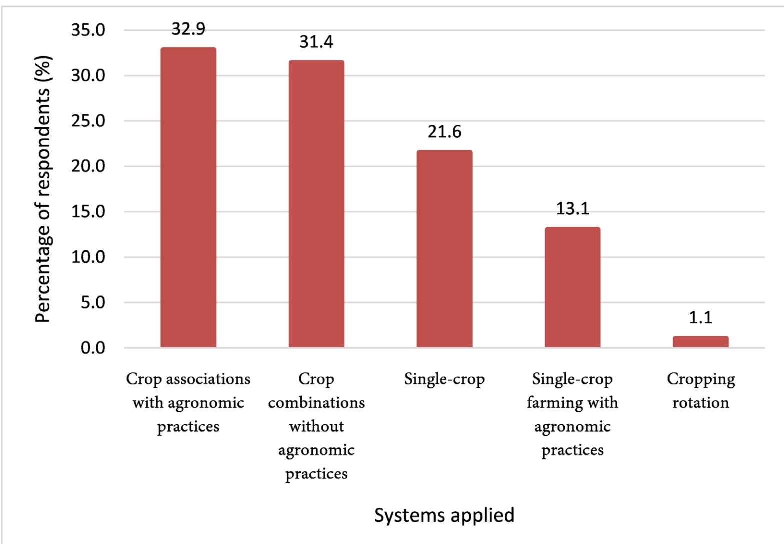

Figure 2. Production system frequently used to grow beans.

Figure 2 shows that beans' farmers use various systems of production as:

- Crops associations or combinations with agronomic practices system that is practiced by 93 respondents out of 283 i.e. 32.9%;
- Crops combinations or associations without agronomic practices system that practiced by 89 respondents out of 283, i.e. 31.4%;
- Single crop production system practiced by 61 out 283 respondents, i.e. 21.6%;
- Single-crop farming with agronomic practices system practiced by 37 respondents out of 283, i.e. 13.1%;
- Cropping rotation practiced by only 3 out of 283 respondents, i.e. 1.1%.

Results from Figure 3 show that 241 out of 283 respondents that means 85.2% of our respondents use organo-mineral fertilizers or manures while 42 respondents, i.e. 14.8% do not do such practice system.

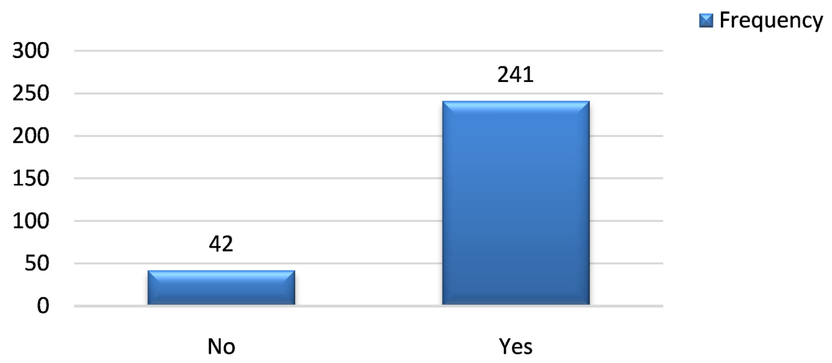

Figure 3. Use of organo-mineral fertilisers.

During season 2022 A, Table 1 shows that among 283 respondents to our questionnaire, 240 representing 49.5% answered that they produced zero kilos. 17 households (6%) produced 20kg each, 14 households (4.9) produced 30 kilos each, and 20 produced 50 kilos. Other quantities were produced by less than 10 households.

Table 1. Estimated household production of bean variety one for 2022A (kg) on their farm.

Production in kilos	Frequency	Percentage	Valid percentage
0	140	49.5	49.5
4	1	0.4	0.4
5	3	1.1	1.1
6	1	0.4	0.4
8	1	0.4	0.4
10	8	2.8	2.8
11	1	0.4	0.4
12	2	0.7	0.7
14	1	0.4	0.4

Continued

15	5	1.8	1.8
18	1	0.4	0.4
20	17	6.0	6.0
23	1	0.4	0.4
25	6	2.1	2.1
27	1	0.4	0.4
28	1	0.4	0.4
29	1	0.4	0.4
30	14	4.9	4.9
32	2	0.7	0.7
35	1	0.4	0.4
36	1	0.4	0.4
38	2	0.7	0.7
40	9	3.2	3.2
45	1	0.4	0.4
48	1	0.4	0.4
50	20	7.1	7.1
58	1	0.4	0.4
60	4	1.4	1.4
70	4	1.4	1.4
80	4	1.4	1.4
90	1	0.4	0.4
100	9	3.2	3.2
105	1	0.4	0.4
115	1	0.4	0.4
120	1	0.4	0.4
150	8	2.8	2.8
155	1	0.4	0.4
170	1	0.4	0.4
200	2	0.7	0.7
272	1	0.4	0.4
300	1	0.4	0.4
750	1	0.4	0.4
Total	283	100.0	100.0

During season 2022 B, **Table 2** emphasizes the situation showing that the 1st category is occupied households that produced less than 1 kilo. 36 respondents representing 12.7%; 18 respondents (6.4%) produced 50 kilos. Another group of 18 respondents produced 100kilos; 14 (4.9%) said they produced 15 kilos; 13 (4.6%) produced 10 kilos; a category made of 11 households (3.9%) produced 10kilos and another category of the same number of households produced 200kilos; and a category of 10 households produced 20 kilos.

Table 2. Estimated household production of bean variety one for 2022B (kg) on their farm.

Production in kilos	Frequency	Percentage	Valid percentage	Cumulated percentage
0	36	12.7	12.7	12.7
2.5	1	0.4	0.4	13.1
5.0	7	2.5	2.5	15.5
6	4	1.4	1.4	17.0
8	1	0.4	0.4	17.3
10	13	4.6	4.6	21.9
12	4	1.4	1.4	23.3
15	14	4.9	4.9	28.3
16	2	0.7	0.7	29.0
17	1	0.4	0.4	29.3
20	10	3.5	3.5	32.9
21	1	0.4	0.4	33.2
23	1	0.4	0.4	33.6
25	9	3.2	3.2	36.7
28	1	0.4	0.4	37.1
29	1	0.4	0.4	37.5
30	11	3.9	3.9	41.3
35	9	32	3.2	44.5
37	1	0.4	0.4	44.9
40	5	1.8	1.8	46.6
45	7	2.5	2.5	49.1
50	18	6.4	6.4	55.5
53	1	0.4	0.4	55.8
56	2	0.7	0.7	56.5
57	1	0.4	0.4	56.9
58	1	0.4	0.4	57.2
60	5	1.8	1.8	59.0
62	1	0.4	0.4	59.4
65	1	0.4	0.4	59.7
67	1	0.4	0.4	60.1
68	1	0.4	0.4	60.4
70	9	3.2	3.2	63.6
75	1	0.4	0.4	64.0
76	1	0.4	0.4	64.3
80	8	2.8	2.8	67.1
85	1	0.4	0.4	67.5

Continued

90	4	1.4	1.4	68.9
100	18	6.4	6.4	75.3
105	2	0.7	0.7	76.0
110	3	1.1	1.1	77.0
115	1	0.4	0.4	77.4
120	5	1.8	1.8	79.2
130	2	0.7	0.7	79.9
150	9	3.2	3.2	83.0
170	1	0.4	0.4	83.4
180	1	0.4	0.4	83.7
200	11	3.9	3.9	87.6
215	1	0.4	0.4	88.0
220	1	0.4	0.4	88.3
250	7	2.5	2.5	90.8
270	1	0.4	0.4	91.2
275	1	0.4	0.4	91.5
300	7	2.5	2.5	94.0
350	2	0.7	0.7	94.7
380	2	0.7	0.7	95.4
400	2	0.7	0.7	96.1
450	2	0.7	0.7	96.8
500	2	0.7	0.7	97.5
520	1	0.4	0.4	97.9
550	1	0.4	0.4	98.2
560	1	0.4	0.4	98.6
600	1	0.4	0.4	98.9
760	1	0.4	0.4	99.3
850	1	0.4	0.4	99.6
1000	1	0.4	0.4	100.0
Total	283	100	100	

During the season 2022 C, **Figure 4** shows that out of 283 respondents, 264 corresponding to 93.3% did not produce any kilo of beans.

During season 2023 A, **Table 3** shows 103 respondents (corresponding to 36.4%) did not produce even a single kilo of beans. In number, this was followed by 25 respondents (8.8%) confirming that they produced 50 kilos; 17 (6%) produced 30 kilos; 14 (4.9%) produced 20kilos; and 10 produced only 15 kilos and another category of 10 produced 150 kilos.

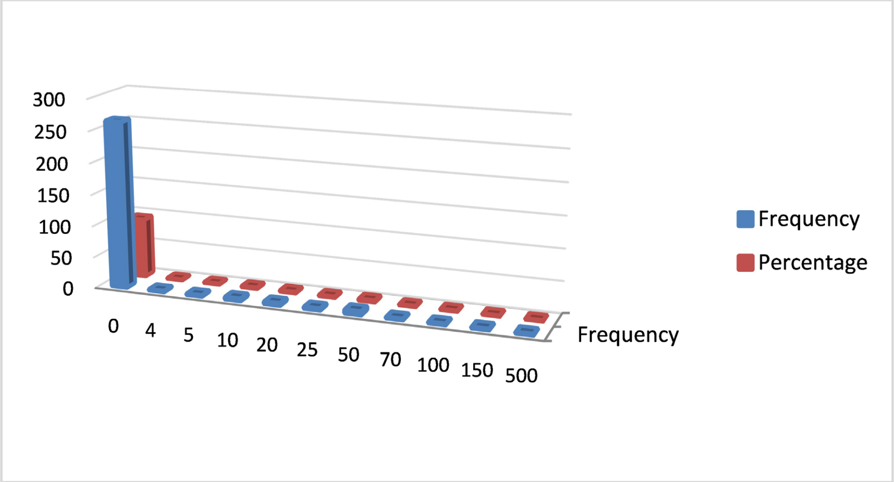

Figure 4. Estimated production of bean variety one for 2022C.

Table 3. Estimated household production of bean variety one for 2023A (in kg) on their farm.

	Production in kilos	Frequency	Percentage
Valid	0	103	36.4
	3	1	0.4
	5	3	1.1
	6	1	0.4
	10	9	3.2
	11	1	0.4
	12	3	1.1
	15	10	3.5
	16	1	0.4
	18	1	0.4
	20	14	4.9
	25	8	2.8
	26	2	0.7
	27	1	0.4
	28	1	0.4
	30	17	6.0
	35	5	1.8
	37	2	0.7
	38	2	0.7
	40	12	4.2
	42	2	0.7
	45	2	0.7

Continued

46	1	0.4
48	2	0.7
50	25	8.8
54	1	0.4
58	1	0.4
60	7	2.5
65	1	0.4
70	4	1.4
75	2	0.7
80	4	1.4
89	1	0.4
90	1	0.4
100	9	3.2
110	2	0.7
120	2	0.7
140	1	0.4
150	10	3.5
170	1	0.4
200	4	1.4
250	1	0.4
450	1	0.4
1050	1	0.4
Total	283	100.0

4. Discussion and Conclusion

Beans farmers use various systems of production as crops associations or combinations with agronomic practices system, crops combinations or associations without agronomic practices system, single crop production system, single-crop farming with agronomic practices system and cropping rotation (See **Figure 2**). Crops combination or association has been remarked in Morocco as innovative systems and technologies to fulfill food, feeding and energy demands and helped to fight against negative impacts of monoculture oriented intensification, agroforestry creating an interest in the international scientific community in regards to the preservation of biodiversity, diversification of productions, alternative solution for climatic change, enhancing agricultural land profitability, livestock integration, and erosion control (Daoui et Fatemi, 2014; Moraine et al., 2014). Crops combination that may be applied as a simple diversification strategy an increasing number of crops grown on separate plots within a farm but also as an intercropping strategy considered as a within-plot increased diversity, where more than one species is grown at the same time and place production variability (Paut et al., 2020). Crop combination may also be implemented as a means of pest management (Barzman et al., 2015).

A single crop production system applied in Burundi (**Figure 2**) has been shown the best way of satisfying the food needs. The example of rice production in China, Nepal, Japan, and India (Gadal et al., 2019) is a key solution to such issue for it enables an easy way of fertilization intensification (Hayashi et al., 2022) as it has been in Kansas, USA (Nelson et al., 2022). Anyway, a single-crop system or agricultural intensification increases crop productivity but is known to simplify production with a lower diversity of cropping systems, higher genetic uniformity, and a higher uniformity of agricultural landscapes (Hufnagel et al., 2020) while local production with it cannot feed more than one-third of the population (Kinnunen et al., 2020).

A large number of Burundians use organo-mineral fertilizers or manure-farming fertilization systems (See **Figure 3**). Organo-mineral fertilizers have given proof of production growth, yield and economic profitability of Bean (Phaseolus vulgaris) in Eastern DRC while the territory suffered low fertility obliging soil fertility management technologies (Chakirwa et al., 2019). Beans farmers require then the integration of inoculants, green manure and organo-mineral fertilization for any of their crops of banana plantations and beans that feed their families (Simo et al., 2020).

As shown by **Figure 5**, results reveal that access to fertilizers differs from the sort of life farmers are living; for 174 out of 283 respondents i.e. 61.5% of our respondents directly purchase manures or fertilizers; 58 respondents i.e. 20.5% buy it on credit; 40 respondents i.e. 14.1% do not access by any means to fertilizers; 8 respondents i.e. have others sources means to buy fertilizers and 3 out of 283 respondents i.e. 1.1% mix credit and direct purchases. Access to soil fertilizers or manures like organic carbon pools is important for maintaining soil productivity and reducing the net CO2 loading of the atmosphere, thus beans production is

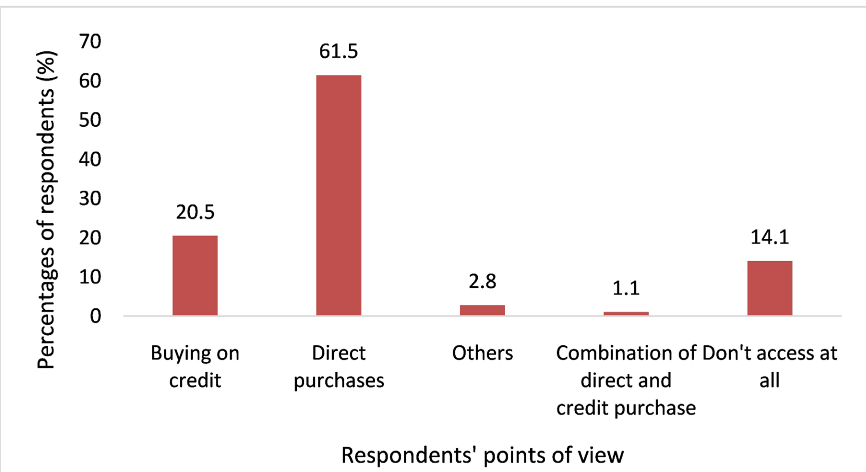

Figure 5. How the region's farmers access fertilizers.

raised (Akpan et al., 2019; Gowing et al., 2020; Ndayisenga & Sindayigaya, 2024; Ndengu et al., 2022; Sabiraguha et al., 2023; Srinivasarao et al., 2014). While there a large part of Burundian population is poor like beans farmers in Northern Rwanda missing money to access fertilizers (Franke et al., 2019), beans production is lowered and households live in bad conditions leading to the worst child's life conditions (Mperejimana & Sindayigaya, 2023; Sindayigaya, 2020, 2022, 2023c; Sindayigaya & Nyabenda, 2022; Toyi & Sindayigaya, 2023).

These two are followed by provincial offices of farming national system (4.6%) and seeds multiplier companies (3.5%). The role played by NGOs and donators is very low occupying 0.4% each, in seeds provisions.

Results from **Figure 6** demonstrate that beans' farmers get seeds from their own stock, meaning a big part of 170 out 60.1% of our respondents; that the local market or the market in the region is the 2nd main supplier of seeds, providing them to 88 out of 283 respondents i.e. 31.1%. Smallholder farmers in Burundi need to have their own stocks to get legume and bean seeds (Sindayigaya & Toyi, 2023b, 2023a; Sperling et al., 2021b) and play a key role in food crop seed production for the community by their operational structures (Dey et al., 2022) till they are considered as backbone in seed production (Sperling et al., 2020). Provincial offices of the farming national system produce 4.6% of seeds and seeds multiplier companies offer 3.5%. The role played by NGOs and donors is very low occupying 0.4% each, in seeds provisions. This joins the idea that there is also a part of informal systems in seed production as is the case in Tanzania (Sperling et al., 2021a). 226 out of 283 respondents i.e. 79.9% do not use pesticides in bean production while the remaining part of our respondents (57 respondents representing 20.1%) use fertilizers (See **Figure 7**). A few Burundians use compost to fertilize their bean faming crops. The same situation is noticed in growing coffee especially beneficiating from coffee factory waste composting, a means of transforming coffee factory waste into organic fertilizers (Nsabimana et al., 2013). Information on potential

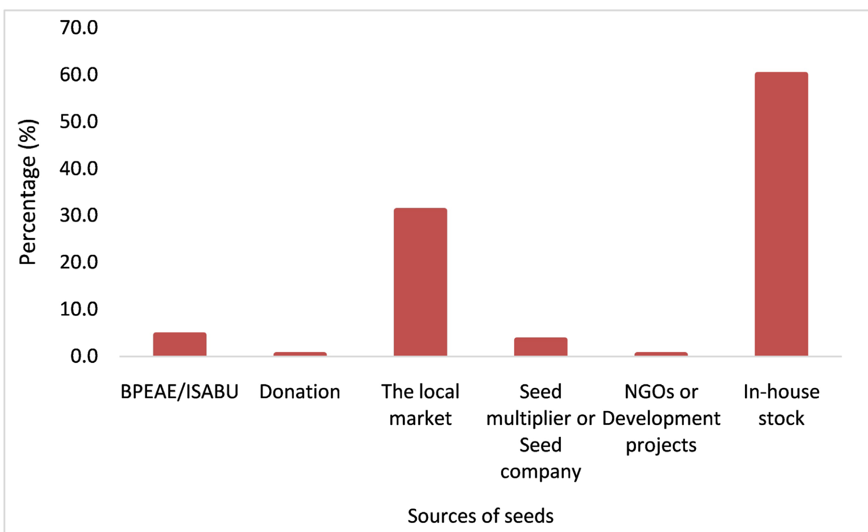

Figure 6. Major source of seeds.

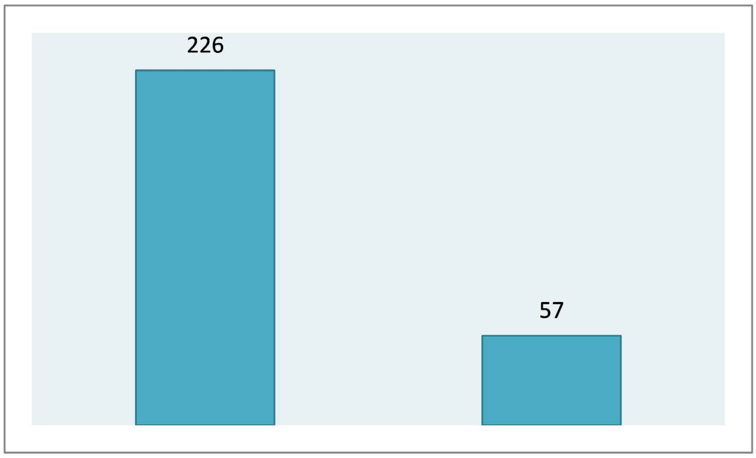

Figure 7. Pesticide use in bean production.

co-composting coffee pulp with ou without decomposition accelerators is lacking in the Burundi agricultural sector (Nduwimana & Sindayigaya, 2023a, 2023b). Compost is testifying the performance in the production due to soil fertility in crops of potato and green beans permitting a good and effective mixture of compost and mineral fertilizer (Temgoua et al., 2023).

Results show that 252 out of 283 respondents representing 89% do know the use or do not use dolomite and only 31 respondents corresponding to 11% use dolomite (See Figure 8). This is a big issue for bean farmers in the Burundian system who do not consider the dolomite use. Notably, dolomite uses interference to help the adsorption of sodium oleate, leading to a substantial decrease in the hydrophobicity of dolomite and realizing the selective inhibition of dolomite in scheelite flotation (Jonya et al., 2023; Sindayigaya et al., 2016; Ziming et al., 2023). Dolomite use is a key to suboptimal soil productivity in agricultural land that increases food production needs (Benavides Bolano, 2019; Rachman et al., 2021).

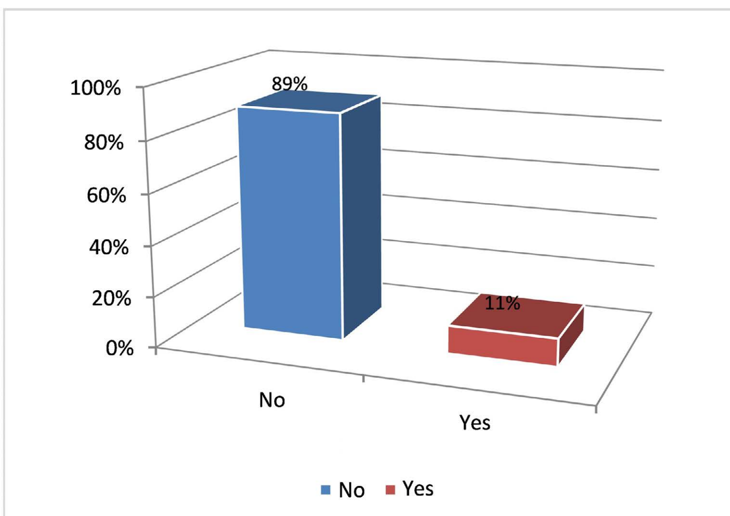

Figure 8. The use of dolomite for bean production.

Figure 9 illustrates that mixing agriculture and farming is a key to accessing manure or fertilizers. Cows farming alone is the first main source of fertilizers for they provide fertilizers to all 136 respondents corresponding to 48.1%. Pigs and goats come second providing correspondingly to 18% and 17.7% of our respondents. The following is compost with 6.7%, others (not precise sort) with 5.7% chickens with 2.1% organic manures with 0.7%, and at last position scale farming with 0.4%. Organic fertilizers, green manures and mixtures of the two witness the potentiality to take a place of inorganic fertilizers used in various crops (Rothé et al., 2019). Mixing helped as manure management favorite to promote sustainable agriculture, and increasing crop production for smallholder farmers in sub-Saharan Africa (Ciza & Sindayigaya, 2023; Mpabansi, 2023; Ndambi et al., 2019).

In consequence of not accessing to fertilizers and manure, not using dolomite and not growing crops according to agronomics systems councils, beans harvest per households has been very low (See Table 1, Table 2 and Figure 4).

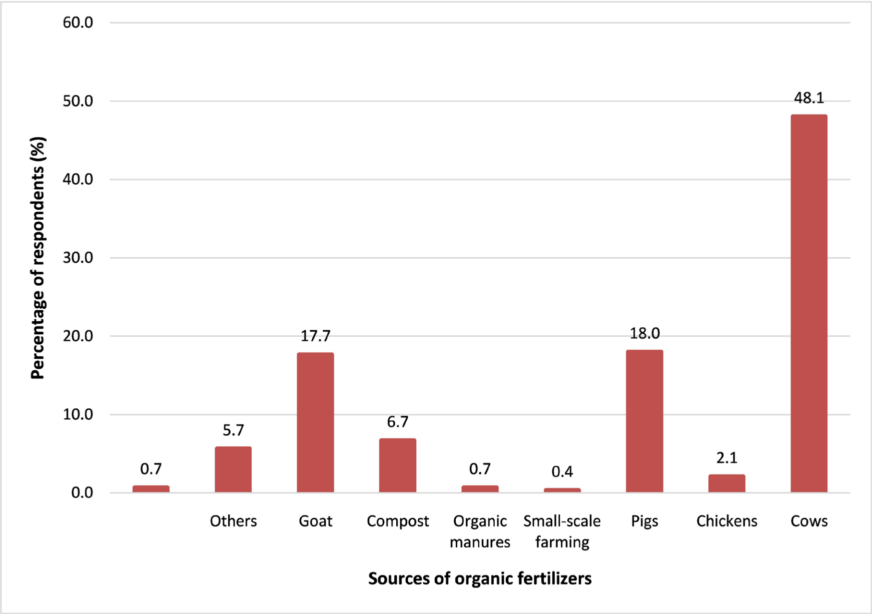

Figure 9. Main source of manure used on your farm.

5. Conclusion

This article aimed to survey the Burundian applications of growing common bean in the acid land of Burundi. Results show that due to poverty among households, small farmers cannot afford the price of fertilizers and dolomite. They try to apply manures but the production is still very low. They do not even follow councils from farming instructors but rather, they grow beans in association with other plants while they were recommended to separate seeds in their crops.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Akpan, S. B., Udo, U. J., & Akpan, P. J. (2019). Analysis of the Gross Margins and Commercialization of Manure and Fertilizer Based Waterleaf (*Talinum triangulare*) Farmers in Nigeria. *Agricultural and Resource Economics: International Scientific E-Journal, 5,* 5-31. https://doi.org/10.51599/are.2019.05.04.01

Aznar-Sánchez, J. A., Piquer-Rodríguez, M., Velasco-Muñoz, J. F., & Manzano-Agugliaro, F. (2019). Worldwide Research Trends on Sustainable Land Use in Agriculture. *Land Use Policy, 87,* Article ID: 104069. https://doi.org/10.1016/j.landusepol.2019.104069

Barzman, M., Bàrberi, P., Birch, A. N. E., Boonekamp, P., Dachbrodt-Saaydeh, S., Graf, B. et al. (2015). Eight Principles of Integrated Pest Management. *Agronomy for Sustainable Development, 35,* 1199-1215. https://doi.org/10.1007/s13593-015-0327-9

Beltran-Peña, A., Rosa, L., & D'Odorico, P. (2020). Global Food Self-Sufficiency in the 21st Century under Sustainable Intensification of Agriculture. *Environmental Research Letters, 15,* Article ID: 095004. https://doi.org/10.1088/1748-9326/ab9388

Benavides Bolanos, J. A. (2019). Evaluation of Phytoextractor Plants and Dolomite Lime as Strategies to Manage CD in Soils Growing Cacao (*Theobroma cacao* L.) and Spinach (*Spinacia oleracea*). Master's Thesis, The Pensylvania State University. https://etda.libraries.psu.edu/catalog/16695jab1106

Chakirwa, Z. P., Murhi, M. I., Aksanti, K. C., Masirika, F. C., Banyanga, N. E., & Lubobo, A. K. (2019). Effect of Organo-Mineral Fertilization on the Growth, Yield and Economic Profitability of Bean (*Phaseolus vulgaris*) in Eastern DRC. *International Journal of Scientific Research and Management, 7,* 1218-1231. https://doi.org/10.18535/ijsrm/v7i7.em01

Ciza, D., & Sindayigaya, I. (2023). The Repression of the Solicitation of Children for Sexual Purposes Online (Grooming) in Burundian Positive Law. *Applied Mathematical Sciences, 17,* 461-467. https://doi.org/10.12988/ams.2023.917445

Daoui, K., & Fatemi, Z. E. A. (2014). Agroforestry Systems in Morocco: The Case of Olive Tree and Annual Crops Association in Saïs Region. In M. Behnassi, S. Shahid, & N. Mintz-Habib (Eds.), *Science, Policy and Politics of Modern Agricultural System* (pp. 281-289). Springer Netherlands. https://doi.org/10.1007/978-94-007-7957-0_19

Dey, B., Visser, B., Tin, H., Mahamadou Laouali, A., Baba Toure Mahamadou, N., Nkhoma, C. et al. (2022). Strengths and Weaknesses of Organized Crop Seed Production by Smallholder Farmers: A Five-Country Case Study. *Outlook on Agriculture, 51,* 359-371. https://doi.org/10.1177/00307270221115454

Duque-Acevedo, M., Belmonte-Ureña, L. J., Cortés-García, F. J., & Camacho-Ferre, F. (2020). Agricultural Waste: Review of the Evolution, Approaches and Perspectives on Alternative Uses. *Global Ecology and Conservation, 22,* e00902. https://doi.org/10.1016/j.gecco.2020.e00902

Faye, A., Faye, A., Sagna, N., Yessoufou, A. N. D., Zagre, I., Ewulo, R., Worou, N., & Whitbread, A.M. (2022). *Inventaire des technologies et pratiques de l'Agriculture Intelligente face au climat (AIC) au Sénégal.* https://cgspace.cgiar.org/handle/10568/126627

Franke, A. C., Baijukya, F., Kantengwa, S., Reckling, M., Vanlauwe, B., & Giller, K. E. (2019). Poor Farmers—Poor Yields: Socio-Economic, Soil Fertility and Crop Management Indicators Affecting Climbing Bean Productivity in Northern Rwanda. *Experimental Agriculture, 55,* 14-34. https://doi.org/10.1017/s0014479716000028

Gadal, N., Shrestha, J., Poudel, M. N., & Pokharel, B. (2019). A Review on Production Status and Growing Environments of Rice in Nepal and in the World. *Archives of Agriculture* *and Environmental Science, 4,* 83-87. https://doi.org/10.26832/24566632.2019.0401013

Gowing, J. W., Golicha, D. D., & Sanderson, R. A. (2020). Integrated Crop-Livestock Farming Offers a Solution to Soil Fertility Mining in Semi-Arid Kenya: Evidence from Marsabit County. *International Journal of Agricultural Sustainability, 18,* 492-504. https://doi.org/10.1080/14735903.2020.1793646

Hayashi, K., Tokida, T., Arai, M., Sakai, H., Nakamura, H., & Hasegawa, T. (2022). Fertilizer-Derived Nitrogen Use of Two Varieties of Single-Crop Paddy Rice: A Free-Air Carbon Dioxide Enrichment Study Using Polymer-Coated ^{15}N-Labeled Urea. *Soil Science and Plant Nutrition, 68,* 41-52. https://doi.org/10.1080/00380768.2021.2003163

He, C., Tang, C., Li, C., Yuan, J., Tran, K., Bach, Q. et al. (2018). Wet Torrefaction of Biomass for High Quality Solid Fuel Production: A Review. *Renewable and Sustainable Energy Reviews, 91,* 259-271. https://doi.org/10.1016/j.rser.2018.03.097

Hufnagel, J., Reckling, M., & Ewert, F. (2020). Diverse Approaches to Crop Diversification in Agricultural Research. a Review. *Agronomy for Sustainable Development, 40,* Article No. 14. https://doi.org/10.1007/s13593-020-00617-4

Jonya, J. C., Toyi, O., Ndendi, A. A., & Sindayigaya, I. (2023). Qualification and Employability of Women in Burundian Public Industrial Tea and Energy Companies. *Applied Mathematical Sciences, 17,* 445-452. https://doi.org/10.12988/ams.2023.917425

Kinnunen, P., Guillaume, J. H. A., Taka, M., D'Odorico, P., Siebert, S., Puma, M. J. et al. (2020). Local Food Crop Production Can Fulfil Demand for Less than One-Third of the Population. *Nature Food, 1,* 229-237. https://doi.org/10.1038/s43016-020-0060-7

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A Review of Social Science on Digital Agriculture, Smart Farming and Agriculture 4.0: New Contributions and a Future Research Agenda. *NJAS: Wageningen Journal of Life Sciences, 90,* 1-16. https://doi.org/10.1016/j.njas.2019.100315

Kopittke, P. M., Menzies, N. W., Wang, P., McKenna, B. A., & Lombi, E. (2019). Soil and the Intensification of Agriculture for Global Food Security. *Environment International, 132,* Article ID: 105078. https://doi.org/10.1016/j.envint.2019.105078

Lajoie-O'Malley, A., Bronson, K., van der Burg, S., & Klerkx, L. (2020). The Future(s) of Digital Agriculture and Sustainable Food Systems: An Analysis of High-Level Policy Documents. *Ecosystem Services, 45,* Article ID: 101183. https://doi.org/10.1016/j.ecoser.2020.101183

Lal, R. (2020). Home Gardening and Urban Agriculture for Advancing Food and Nutritional Security in Response to the COVID-19 Pandemic. *Food Security, 12,* 871-876. https://doi.org/10.1007/s12571-020-01058-3

Moraine, M., Duru, M., Nicholas, P., Leterme, P., & Therond, O. (2014). Farming System Design for Innovative Crop-Livestock Integration in Europe. *Animal, 8,* 1204-1217. https://doi.org/10.1017/s1751731114001189

Mpabansi, P. (2023). The Extent to Which the 1969 Organization of African Unity Convention Is Used Concerning the 1951 Geneva Convention in Determining the Status of Refugees in Burundi. *Applied Mathematical Sciences, 17,* 281-287. https://doi.org/10.12988/ams.2023.917385

Mperejimana, A., & Sindayigaya, I. (2023). Continuity or Rupture: An Analysis of the Fourth Cycle Literature Teaching Program in the Post-Fundamental Schools, Language Section. *OALib, 10,* 1-9. https://doi.org/10.4236/oalib.1110752

Nasirahmadi, A., & Hensel, O. (2022). Toward the Next Generation of Digitalization in Agriculture Based on Digital Twin Paradigm. *Sensors, 22,* Article 498. https://doi.org/10.3390/s22020498

Ndambi, O. A., Pelster, D. E., Owino, J. O., de Buisonjé, F., & Vellinga, T. (2019). Manure Management Practices and Policies in Sub-Saharan Africa: Implications on Manure Quality as a Fertilizer. *Frontiers in Sustainable Food Systems, 3,* Article 29. https://doi.org/10.3389/fsufs.2019.00029

Ndayisenga, J., & Sindayigaya, I. (2024). The Pedagogy of Integration, the Child in the Center of Education: Participation of the Child in the Schooling Program. *Applied Mathematical Sciences, 18,* 27-34. https://doi.org/10.12988/ams.2024.917431

Ndengu, G., Mponela, P., Chataika, B., Desta, L. T., Chirwa, R., & Sileshi, G. G. (2022). Effect of Combining Organic Manure and Inorganic Fertilisers on Maize-Bush Bean Intercropping. *Experimental Agriculture, 58,* e29. https://doi.org/10.1017/s0014479722000102

Nduwimana, S., & Sindayigaya, I. (2023a). Entry and Mobility in Technical and Vocational Education in Burundi. *Open Journal of Social Sciences, 11,* 11-20. https://doi.org/10.4236/jss.2023.117002

Nduwimana, S., & Sindayigaya, I. (2023b). Establishing Quality in Technical and Vocational Education in Burundi: Contribution of the National Education Forum, Edition 2022 and in Employability in Burundi. *Open Journal of Social Sciences, 11,* 142-153. https://doi.org/10.4236/jss.2023.119010

Nelson, K. S., Patalee, B., & Yao, B. (2022). Higher Landscape Diversity Associated with Improved Crop Production Resilience in Kansas-USA. *Environmental Research Letters, 17,* Article ID: 084011. https://doi.org/10.1088/1748-9326/ac7e5f

Nijimbere, B., Kaboneka, S., Nishimwe, K., Nduwimana, A., Nijimbere, S., & Sindayigaya, I. (2025). Analysis of Common Bean Production Constraints in Burundi's Acid Soils. *Open Journal of Social Sciences, 13,* 63-82. https://doi.org/10.4236/jss.2025.136005

Nsabimana, J. C., Ndayishimiye, N., Kwidera, C., & Beko, A. (2013). *Pauvreté monétaire versus non-monétaire au Burundi.* Partnership for Economic Policy.

Nuhu, H. S., Aliyu, Y. M., & Wadai, A. M. (2023). Assessment of the Role of FAO in Increasing Food Security among Food Crop Farmers in Jere Lga Borno State, Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology, 3,* 160-171. https://doi.org/10.59331/njaat.v3i1.466

Nyabenda, A., & Sindayigaya, I. (2023). The Child's Rights to Quality Food for Children Residing with Their Mothers in Prison: Case of Mpimba Prison, Burundi. *Open Journal of Social Sciences, 11,* 32-40. https://doi.org/10.4236/jss.2023.1111002

Oluseun Adejumo, I., & Adebukola Adebiyi, O. (2020). Agricultural Solid Wastes: Causes, Effects, and Effective Management. In H. M. Saleh (Ed.), *Strategies of Sustainable Solid Waste Management* (pp. 139-154). IntechOpen. https://doi.org/10.5772/intechopen.93601

Pallathadka, H., Mustafa, M., Sanchez, D. T., Sekhar Sajja, G., Gour, S., & Naved, M. (2023). Impact of Machine Learning on Management, Healthcare and Agriculture. *Materials Today: Proceedings, 80,* 2803-2806. https://doi.org/10.1016/j.matpr.2021.07.042

Paut, R., Sabatier, R., & Tchamitchian, M. (2020). Modelling Crop Diversification and Association Effects in Agricultural Systems. *Agriculture, Ecosystems & Environment, 288,* Article ID: 106711. https://doi.org/10.1016/j.agee.2019.106711

Rachman, L. M., Hazra, F., Baskoro, D. P. T., Riskawati, R., & Putri, S. K. (2021). Improvement of Suboptimal Soil Productivity to Growth and Production of Groundnut (*Arachis hypogea* L.). *IOP Conference Series: Earth and Environmental Science, 807,* Article ID: 042072. https://doi.org/10.1088/1755-1315/807/4/042072

Rothé, M., Darnaudery, M., & Thuriès, L. (2019). Organic Fertilizers, Green Manures and

Mixtures of the Two Revealed Their Potential as Substitutes for Inorganic Fertilizers Used in Pineapple Cropping. *Scientia Horticulturae, 257,* Article ID: 108691. https://doi.org/10.1016/j.scienta.2019.108691

Sabiraguha, A., Havyarimana, V., Niyongabo, P., Kamdjoug, J. R. K., Sindayigaya, I., & Niyonsaba, T. (2023). Digital in Higher Education in Burundi. *Open Journal of Social Sciences, 11,* 284-297. https://doi.org/10.4236/jss.2023.1111019

Simo, J. E., Rivera, R. A., Martinez, L. A., & Martin, G. M. (2020). The Integration of AMF Inoculants, Green Manure and Organo-Mineral Fertilization, in Banana Plantations on Calcic Haplic Phaeozems. *Tropical and Subtropical Agroecosystems, 23,* Article No. 8. https://doi.org/10.56369/tsaes.2882

Sindayigaya, I. (2020). *Du respect des droits du nourrisson pendant la vie carcérale de sa mère au Burundi: Cas des prisons centrales de Mpimba et Ngozi-femme.* Ph.D. Thesis, Université du Burundi. https://rgdoi.net/10.13140/RG.2.2.23023.51361

Sindayigaya, I. (2022). Analysis of the Child's Right to Housing Implementation for Street Children in Burundi: Case of Kirundo City. *Applied Mathematical Sciences, 16,* 465-472. https://doi.org/10.12988/ams.2022.916819

Sindayigaya, I. (2023a). Problems Related to the Implementation of Child's Right Birth Registration in Burundi: Proposing Their Remedies. *Open Journal of Social Sciences, 11,* 41-56. https://doi.org/10.4236/jss.2023.119004

Sindayigaya, I. (2023b). The Overview of Burundi in the Image of the African Charter on Rights and Welfare of the Child. *Beijing Law Review, 14,* 812-827. https://doi.org/10.4236/blr.2023.142044

Sindayigaya, I. (2023c). The Overview of Burundi in the Image of the African Charter on Rights and Welfare of the Child. *Beijing Law Review, 14,* 812-827. https://doi.org/10.4236/blr.2023.142044

Sindayigaya, I., & Nyabenda, A. (2022). Infants Residing with Their Mothers at Mpimba Prison, Burundi: Do They Have Rights to Be Protected? *Applied Mathematical Sciences, 16,* 555-563. https://doi.org/10.12988/ams.2022.916865

Sindayigaya, I., & Toyi, O. (2023a). Electricity Public Policy in Burundi: Case of the City of Bujumbura. In *Construisons des partenariats et un réseau durable à travers une recherche une recherche innovante pour la lutte contre la pauvreté et les inégalités socio-économiques* (pp. 9-21). University of Burundi. https://doi.org/10.13140/RG.2.2.25121.17764

Sindayigaya, I., & Toyi, O. (2023b). Water Public Policy in Burundi: Case of the City of Bujumbura. In *Semaine de l'Université: Construisons des partenariat et un réseau durable à travers une recherche innovante pour la lutte contre la pauvreté et les inégalités socio-économiques* (pp. 1-8). University of Burundi. https://doi.org/10.13140/RG.2.2.35148.18565

Sindayigaya, I., Hitimana, B., Mbonigaba, N., & Nyandwi, A. (2016). *Problématique de la repression du crime de viol: Cas de la province judiciaire de Ngozi de 2010 à 2013.* https://www.researchgate.net/publication/369537718_Problematique_de_la_repression_du_crime_de_viol_Cas_de_la_province_judiciaire_de_Ngozi_de_2010_a_2013#fullTextFileContent

Sperling, L., Birachi, E., Kalemera, S., Mutua, M., Templer, N., Mukankusi, C. et al. (2021a). The Informal Seed Business: Focus on Yellow Bean in Tanzania. *Sustainability, 13,* Article 8897. https://doi.org/10.3390/su13168897

Sperling, L., Gallagher, P., McGuire, S., & March, J. (2021b). Tailoring legume seed markets for smallholder farmers in Africa. *International Journal of Agricultural Sustainability,* *19,* 71-90. https://doi.org/10.1080/14735903.2020.1822640

Sperling, L., Gallagher, P., McGuire, S., March, J., & Templer, N. (2020). Informal Seed Traders: The Backbone of Seed Business and African Smallholder Seed Supply. *Sustainability, 12,* Article 7074. https://doi.org/10.3390/su12177074

Srinivasarao, C., Venkateswarlu, B., Lal, R., Singh, A. K., Kundu, S., Vittal, K. P. R. et al. (2014). Long-Term Manuring and Fertilizer Effects on Depletion of Soil Organic Carbon Stocks under Pearl Millet-Cluster Bean-Castor Rotation in Western India. *Land Degradation & Development, 25,* 173-183. https://doi.org/10.1002/ldr.1158

Temgoua, E., Ntangmo Tsafack, H., Azinwi Tamfuh, P., & Ndzana, G. M. (2023). Testing Soil Fertility, Potato (*Solanum tuberosum*) Production and Residual Effect on Green Beans (*Phaseolus vulgaris*) Performance Using Different Rates and Mixtures of Compost and Mineral Fertilizer. *Journal of Plant Nutrition, 46,* 4033-4043. https://doi.org/10.1080/01904167.2023.2220728

Toyi, O., & Sindayigaya, I. (2023). Sociability Networks in the City of Bujumbura. *Open Journal of Social Sciences, 11,* 218-231. https://doi.org/10.4236/jss.2023.118016

Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D. et al. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *International Journal of Environmental Research and Public Health, 18,* Article 1112. https://doi.org/10.3390/ijerph18031112

Victor, B. W. M., Alonga, B. M., Simbananiye, L., Mwilarhe, P. A., & Sindayigaya, I. (2023). Organisational Health and Resilience of Community Health Insurance Schemes in Bukavu Eastern DRC. *Open Journal of Social Sciences, 11,* 378-398. https://doi.org/10.4236/jss.2023.119025

Yasser, B., & Wanis, D. (2021). *Etude de l'application de l'itinéraire tech-nique sur la céréaliculture en zones semi-arides.* https://dspace.univ-bba.dz/items/128325a1-b2ca-43f9-9f33-4ffb7dfc0473

Ziming, W., Bo, F., & Yuangan, C. (2023). The Separation Behavior and Mechanism of Scheelite and Dolomite Using Locust Bean Gum as Depressant. *Minerals Engineering, 202,* Article ID: 108280. https://doi.org/10.1016/j.mineng.2023.108280