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Soil Fertility Management Practices by Smallholder Farmers in the Bamboutos Mountain Ecosystem

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Abstract Low soil fertility is one of the major constraints faced by smallholder farmers in the Bamboutos Mountain ecosystem. A survey of 261 randomly selected smallholder farmers was conducted using a standard questionnaire to identify the major cropping systems used by smallholder farmers, the practices that smallholder farmers use to maintain or improve soil fertility, the types of manure or fertilizer used as well as the major crops grown in the area. An interview schedule was used to collect data and the descriptive statistics used for data analysis. Findings indicated the farmers practiced, inter cropping, crop rotation and agroforestry with intercropping being the most practiced cropping system. The farmers use both organic manures and inorganic fertilizers for crop production with the major organic manure being fowl dropping and the major inorganic fertilizer being N-P-K 20-10-10. To increase soil fertility, 73% of the farmers allow for fallow periods and the dominant vegetation during the fallow were: grasses, grasses + Tithonia and Grasses + shrubs. The major crops planted both organically and with inorganic fertilizers were Potato, cabbage, carrot, maize, beans, leeks and celery.

Keywords: *soil fertility, management practices, crops, smallholder farmers*

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1. Introduction

Soil fertility decrease on smallholder farms is a major problem in sub-Saharan Africa. The soil fertility decline is attributed to nutrient mining through crop harvest without adequate replacement [1]. It is unfortunate that long –term processes that deplete nutrient stocks are less visible and receive lower priority [2]. Soil fertility is influenced by both land use and soil management practices; fertilization, cropping systems and farming practices at field scale [3].

Inorganic fertilizer is expensive and largely unaffordable to the resource-poor farmers found mostly across Sub Saharan Africa [4]. Smallholder farmers in Cameroon lack financial resources to purchase adequate quantities of mineral fertilizers to correct the inherent low fertility levels and replace the nutrients exported with harvested produce [5]. Yet restoring soil N and P are major priorities not only for sustained productivity but also in the rehabilitation of eroded and degraded soils. There is little option to use fertilizers to balance the loss of P and K, but N can also be supplied through Biological Nitrogen Fixation (BNF). On the other hand, application of organic inputs either as animal manures or crop residues is insufficient to meet the crop nutrient requirements [6]. Many technologies have been used to maintain or improve soil fertility with more emphasis on integrated soil fertility management. The sole use of inorganic (mineral) fertilizer not successful in the tropics as well as the sole use of organic fertilizers is limited by their bulkiness, unviability, low quality and slow release of nutrients. Combination of organic and mineral inputs has been advocated as a sound management practice for smallholder farming systems in the tropics. It was concluded in that, combined application of manure and fertilizer helps to increase crop productivity and quality while maintaining soil fertility [7]. Although these fertilizers are needed to sustain long term soil fertility, neither of the two inputs is usually in sufficient amounts to satisfy farmers need [8].

Besides organic and inorganic inputs, farming practices such as agroforestry constitute promising option for maintaining the stability of landscapes and soils that are subjected to human activities. The integration of agriculture and forestry within production system will solve the problems of conflicting demand for food, land for timber/fuel food production, drinking water and soil fertility decline [9]. Some farmers practice fallowing to allow time for the

fertility of their soils to improve [10]. Intercropping has also been found to maintain soil fertility [11].

The Mount Bamboutos is a group of volcanoes based on a swell in the Cameroon Volcanic Line shared by three regions of Cameroon, merging in the north with the Oku Volcanic [12]. Due to population pressure, farming is carried out on the steep slopes, leading to erosion and loss of nutrients. Cattle grazing is a common practice on the upper slopes where food crop cultivation is uneconomical [13]. Consequently, the soils have declined in fertility and it is expected that more inputs in form of fertilizers are needed for good yields. Good crop yields are an impetus to attain the national goal of poverty eradication and food security. This study was geared towards understanding the cropping systems of small holder farms with regards to their soil fertility management practices and has the following specific objectives: (i) to identify the practices that smallholder farmers use to maintain or improve soil fertility, (ii) to identify the types of manures or fertilizers used and (iii) identify the major crops grown with these fertilizers in the study area.

2. Methodology

2.1. Study Site

The Bamboutos Mountain is located between latitude 5°32' and 5°51' North of the equator and longitude, 956' and 1009' east of the Greenwich Meridian. It extends from an altitude of 2000m to 2700 m above sea level. It falls under the western High plateau agro ecological zone of Cameroon with multi-agricultural production system. Administratively, the Bamboutos Mountain covers part of the West, South West and North West regions of Cameroon.

Mean maximum temperature is between 20-22°C; mean minimum 13-14˚C. November has the lowest mean minimum temperature and December the highest mean maximum. Temperature inversions at night in narrow valleys which suffer from poor air drainage leads to some ground frost, mainly in January or February. Rainfall varies from 1780 – 2290mm per year. Most rain falls between July and September. Generally January and February have the lowest relative humidity (average 45 - 52 %). The monthly average humidity exceeds 80% in July and August. During the rainy season, mist and low cloud occur frequently. The soils of the Bamboutos mountain are organised into three main categories: soils with andic characteristics in the upper region of the mountain (lithic dystrandept soils, typical dystrandept soils and oxic dystrandept soils); ferrallitic soils in the lower part of the mountain (typical haplohumox soils and typical kandiudox soils) and imperfectly developed soils (tropopsamment soils and umbraquox soils) [14].

2.2. Data Collection

A survey was conducted in 11 villages around the Mount Bamboutos. The target population was the smallholder farmers. A total of 261 farmers were randomly selected from these villages. The questionnaire was designed to capture the following information about the farmers; their socio economic status, the different farming systems used, types of fertilizers used and the main crops planted. Most farmers had more than one farm where they plant different crops and practiced different cropping systems. Interview schedules were used to collect data while descriptive statistics were the main analytical technique. Farmers were interviewed individually and data collected was analyzed using the Statistical Package for Social Sciences (SPSS) and summarized using graphs.

3. Results and Discussion

3.1. Socio Economic Characteristics of Farmers

A majority of the farmers were men (69 %) and most (84%) of the farmers were literate having at least primary school education. The average age of farmers was 49 years and total farm sizes varied from 0.02 to 9 ha. Similar results were obtained while studying the agricultural practices on the Bamboutos Mountain [15]. Out of the sampled population, 98% confirmed that agriculture is their main source of income and 80% of the farmers had lived in their respectively villages for more than 15 years.

3.2. Smallholder Farmers` soil Fertility Management Practices

Figure 1 presents the various cropping practices used by farmers to improve soil fertility. Farmers had several farms and were practicing same or different cropping practices in one, two, three, or all their farms. This explains why in the figure we use the number of farms. Details of the various cropping practices are given below.

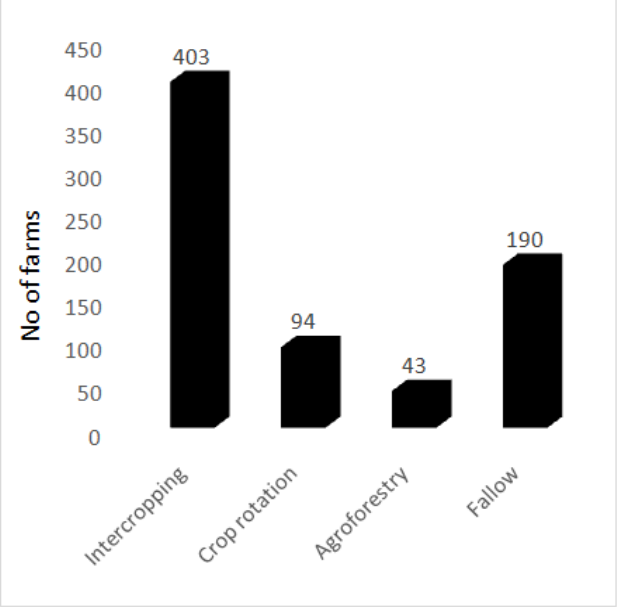

Figure 1. Cropping practices used by small holder farmers to improve soil fertility

Fallow: Allowing a farm to fallow is a strategy that is used to restore the chemical and physical fertility of the soil [10]. Fallow is commonly referred to as a resting period for agricultural land between two cropping cycles during which soil fertility is restored. It has more roles than just soil fertility and these roles include; weed control and interruption of pest and disease cycles, produce wood, fibers and medicinal plants for households and can serve as pasture for livestock [16]. Seventy three percent of the respondents did allow for fallow periods for at least one of their farms. The dominant vegetation during the fallow period were grass, shrubs and Tithonia (Figure 2). Tithonia is known to be a good fertilizer tree when incorporated into the soil [17]. Tithonia leaves have been found to have a high concentration of nutrients; average concentration of green leaves were 3.5% N, 0.37% P and 4.1% K on dry matter basis [18]. Tithonia green manure applied at 9t/ha equivalent of dry matter was found to produce higher fresh weight of green vegetables compared to calcium ammonium nitrate applied at the same rate [19]. Tithonia has nematocidal properties, reducing disease problems in the subsequent cropping phase. Besides the afo-mentioned advantages, Thithonia fallow require little labour, establish spontaneously when seed is available, require no special management and are easily cleared [20]. Most farms had grass as vegetation during the fallow period which could be used as fodder for animals. Shrubs could be used as fuel wood.

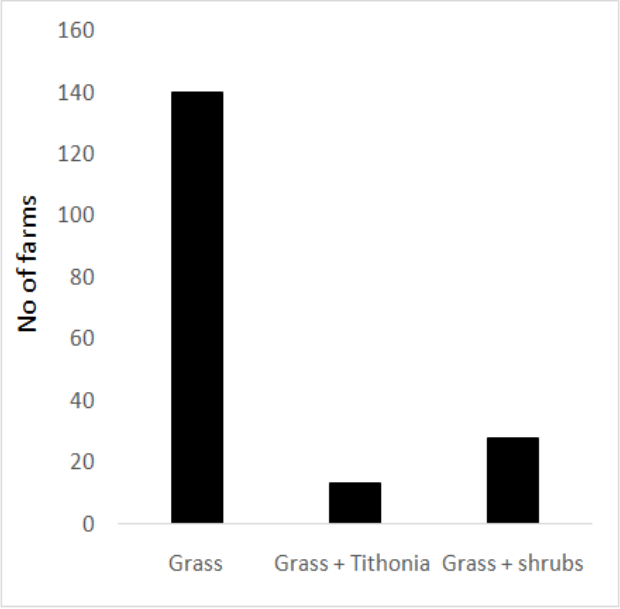

Figure 2. Dominant vegetation during the fallow period

3.2.1. Crop Rotation

Another approach used by farmers in the study area to maintain/improve soil fertility is practicing crop rotation. This is the practice of growing several different crops on the same piece of land in years or seasons. It is usually practiced to replenish soil and curb pests and diseases. An efficient crop rotation practice is that involving a legume and a cereal crop where the legumes add nitrogen to the soil through biological nitrogen fixation [21]. Crop rotation was practiced in at least 94 farms (Figure 1). Various farmers used different sequences depending on their objectives. The sequences went up to 5 for some farmers. The crops could be grouped into four main categories: legumes: beans (Phaseolus vulgaris), groundnuts), root vegetables (carrots, potato (Solanum tuberosum), leafy vegetables (cabbages, leeks) and fruit bearing: maize (Zea mays). Similar crops were used by organic farmers in England practicing crop rotation [22]. The major crops were virtually the same no matter the sequence. Potato was the most planted crop in most of the sequences (Figure 3). Cropping in the study area has been categorized as potato-based cropping system [6]. Legume – maize rotations were found to improve maize yields and improve soil fertility (increase total N, available P, exchangeable K, Mg and effective cation exchange capacity) [23].

3.2.2. Intercropping

Intercropping which is an agroecosystem management practice where more than one crop is planted on the same plot of land at the same time [24] was the most practiced cropping system in the study area. Intercropping was practiced in 403 farms (Figure 1). Similar results were obtained when accessing smallholder cropping systems in South Africa [25]. In addition to the fact that intercropping is a major traditional soil management practice, it also ensures food security through diverse food in farms [24]. Considering that the primary goal of a farmer is to get improved crop yields and consequently to get food for his/her household and surplus for income to meet other family needs, farmers perceived intercropping as achieving these benefits. This accounts for the fact that most farmers practiced it. Lack of land for agriculture is also another reason why farmers practiced intercropping. They want to get more out of their land.

3.2.3. Agroforestry

Agroforestry in this case referred to scattered trees on crop land; an agrosilvicultural agroforestry system. In this case, trees/shrubs are either planted or maintained within agricultural lands [26]. Multipurpose trees are combined with agricultural crops on the same land management unit. Trees formed the permanent crops and include fruit trees. Therefore, agroforestry systems combine trees, crops, or livestock to increase diversity, productivity, profitability, and environmental stewardship [27]. Research found that soil properties were ameliorated and an overall increase in nutrient level below the trees in agroforestry systems [28]. In fact, agroforestry as a sustainable land management practice has shown solid evidence of its role in soil fertility improvement [29]. Forty three farms were practicing agroforestry. One of the reasons for low usage of agroforestry practices is the fact that most farmers don`t master the agroforestry techniques and so do not respect the planting distances. In some cases trees are not pruned leading to much shade that affect crop yields as sunlight is reduced.

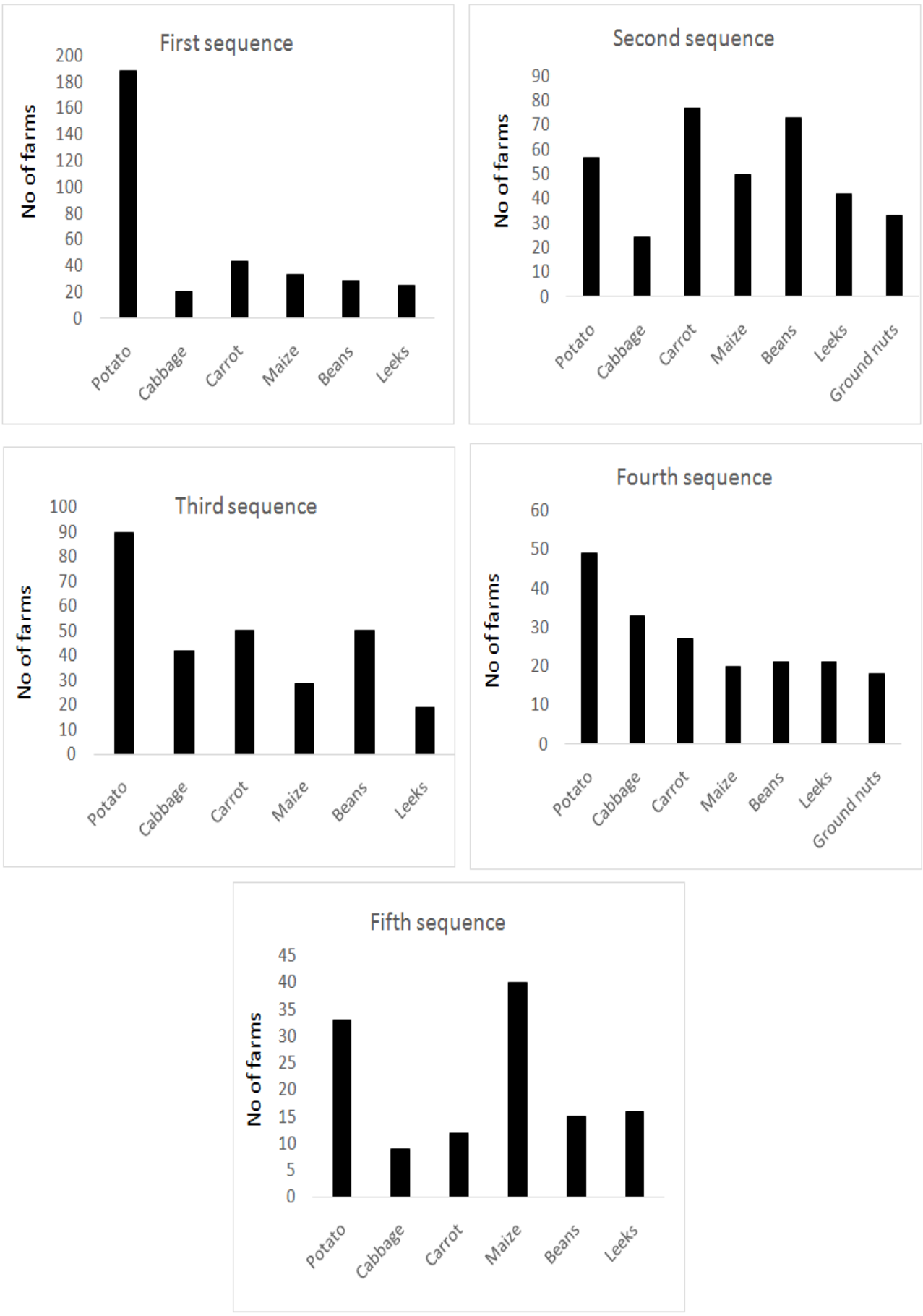

Figure 3. Crops planted during crop rotation

3.2.4. Fertilizer and Manure Application

Inorganic fertilizers and organic manures were used by farmers in the study area. Similar results have also been obtained [30] when studying the intricacies of organic and chemical fertilizer application on arable land crop production in Cameroon. Integrated use of organic and inorganic fertilizers has been recommended for sustainable crop production [31,32]. Ninety four percent of the farmers responded that they use organic manure for crop production. The organic manures were used singly or in combinations (Figure 4). Poultry manure was used in most farms in the study area similar to the results of previous studies [6].

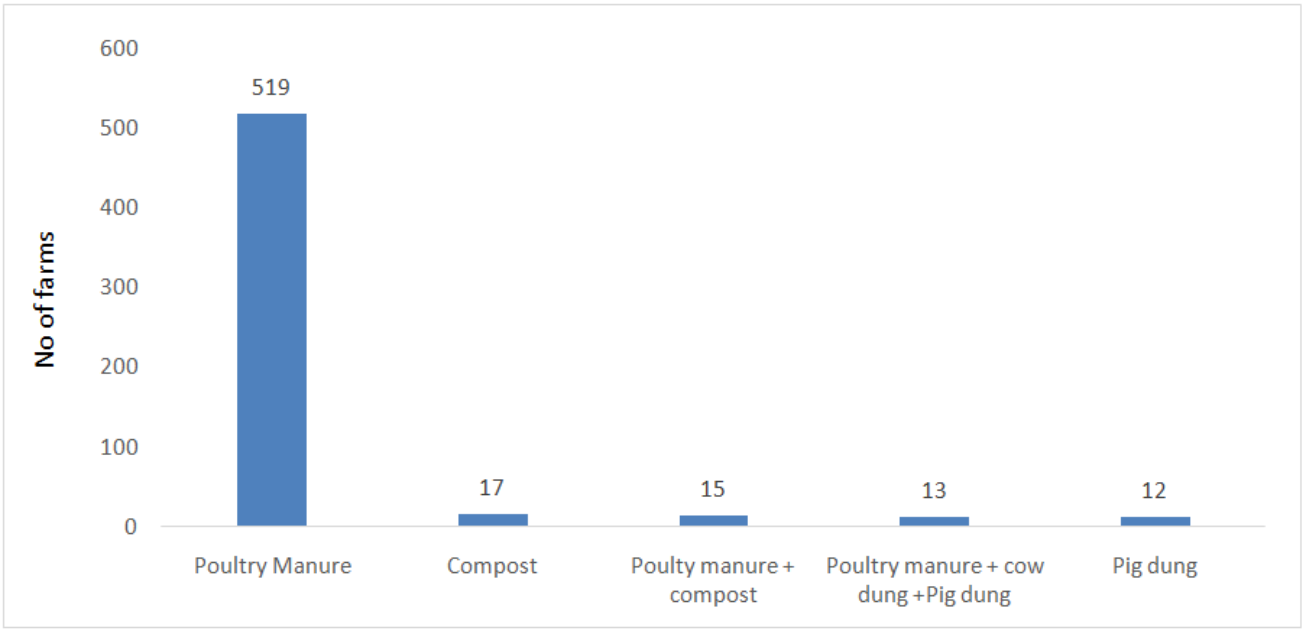

Figure 4. Organic manures used by smallholder farmers

The main organically cultivated crops were potato, carrots and maize (Figure 5).

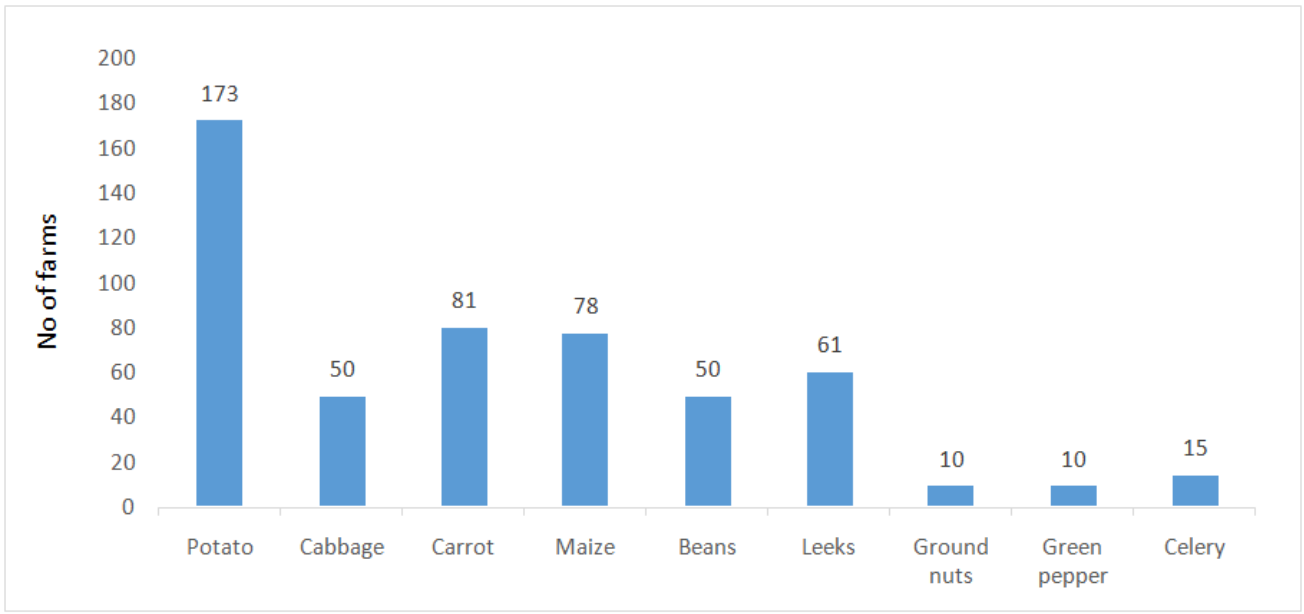

Figure 5. Main organically produced crops

Almost all (96%) of the farmers accepted that they used inorganic fertilizers for crop production. The highest used fertilizer was nitrogen - phosphorus - potassium (N-P-K) 20-10-10 and the least used was foliar fertilizes (Figure 6). The main crops grown with inorganic fertilizers are presented in Figure 7 with potato being the highest crop that is cultivated with inorganic fertilizer. Similar to the situation with organic fertilizers. Most farmers in this area adopted the policy of using both organic and inorganic fertilizers for crop production similar to the practices of other farmers [25,33].

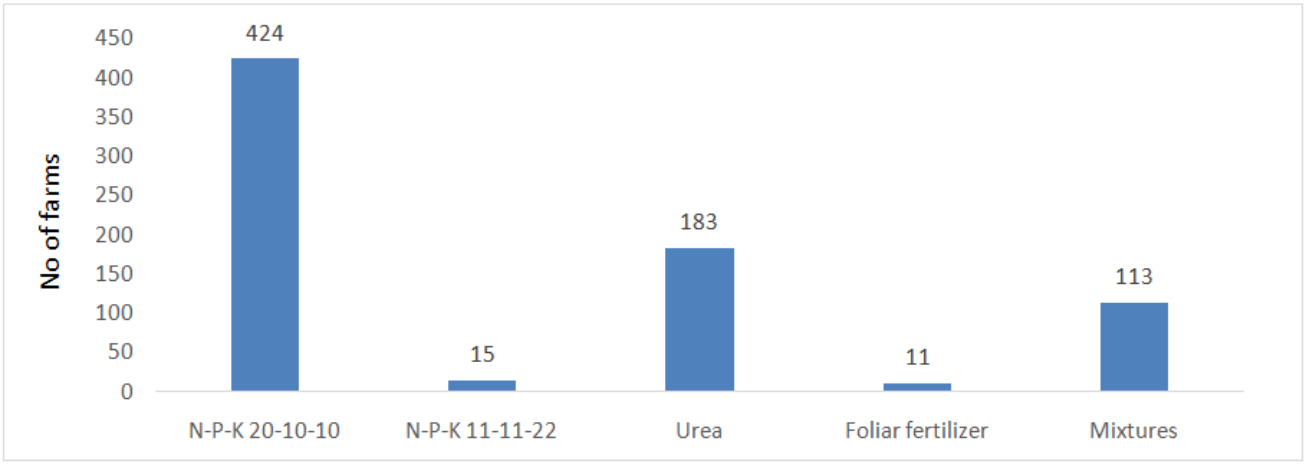

Figure 6. Types of inorganic fertilizers used by farmers

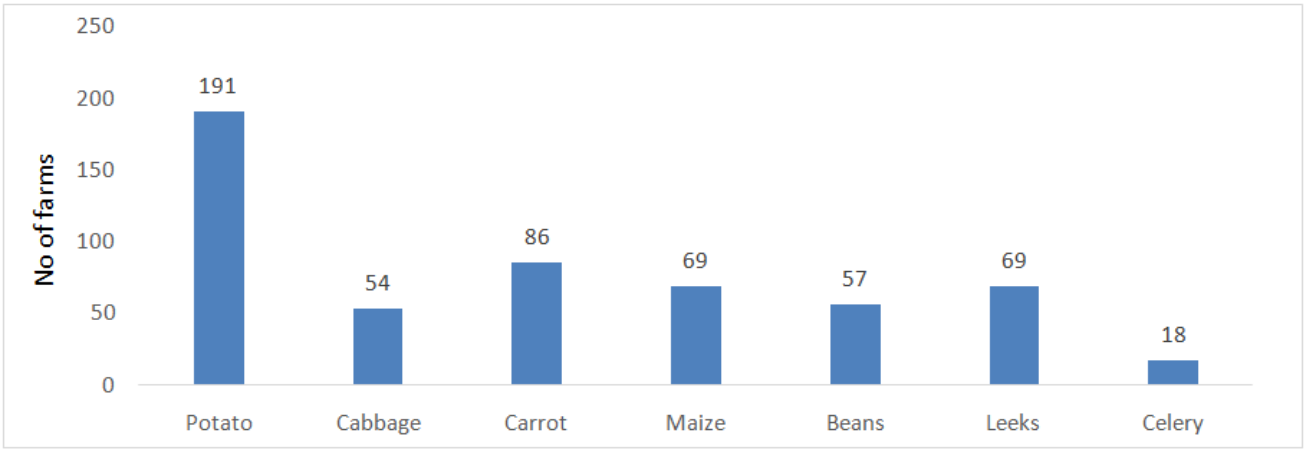

Figure 7. Main crops produced with inorganic fertilizers

4. Conclusion

Small holder farmers in Bamboutos Mountain have adopted some soil fertility management practices. There is however a need for improvement probably through training and supervision in order to get maximum benefits. Intercropping was the most popular cropping system while agroforestry was the least practiced. Both organic and inorganic fertilizers were used for crop production. The main crops produced in the area were potato, maize, beans, cabbage, leeks, celery and cabbage. These crops were produced both organically and with the use of inorganic fertilizers.

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Statement of Competing Interests

The authors have no competing interests.

References

[1] Kanmegne, J. "Slash and Burn Agriculture in the Humid Forest zone of Southern Cameroon: Soil quality Dynamics, Improved Fallow management and Farmers perceptions. PhD Thesis, Wageningen University and Research Centre, 2004.

[2] Ehabe, E.E., Bidzanga, N.L., Mba, C., Njukeng, J.N., Inacio de Barros and Enjlric, F. "Nutrient flows in perennial crop-based farming systems in the humid forests of Cameron" *American Journal of Plant Sciences*, 1, 38-46, 2010.

[3] Henao, J. and Baanante, C, *Agricultural Production and Soil Nutrient Mining in Africa Implications for Resource Conservation and Policy Development*: Summary. In International Center for Soil Fertility and Agricultural Development; IFDC, 2006.

[4] Kugbe, J. X., Wuni, M., Alhassan, M. H., and Maganoba, C, "Increase in The Use of Organic Fertilizers as Complements to Inorganic Fertilizers in Maintenance of Soil Fertility and Environmental Sustainability" *World Journal of Agricultural and Soil Sciences*, 4(1), 2019.

[5] Yengoh, G.T, "Determinants of yield differences in small-scale food crop farming systems in Cameroon" *Agriculture & Food Security*, 1(19), 2012. http://www.agricultureandfoodsecurity.com/content/1/1/19.

[6] Tabi, F.O., Bitondo, D., Yinda, G.S., Kengmegne S.S.A and Ngoucheme, M, "Effect of long- term integrated soil fertility management by local farmers on nutrient status of a Typic Dystrandept under potato-based cropping system", *International Research Journal of Agricultural Science and Soil Science*,.3(4), 134-140, 2013.

[7] Anwar, M., Patra D. D., Chand, S., Kumar, A, Naqvi, A. A. and Khanuja, S. P. S. (2004), "Effect of Organic Manures and Inorganic Fertilizer on Growth, Herb and Oil Yield, Nutrient Accumulation, and Oil Quality of French Basil" *Communications in Soil Science and Plant Analysis*, 36. 13-14, 2005.

[8] Vanlauwe, B and Zingore, S, "Integrated soil fertility management: n operation definition and consequences for implementation and dissemination", *Better Crops*, 95 (3), 4-7, 2011.

[9] Amare, D., Ondie, M., Mekuria, nv Darr, D. "Agroforestry of smallholder farmers in Ethiopia: practices and benefits", *Small-Scale Forestry*, 18(1), 39-56, 2018.

[10] Wezel, A and Haigis, J, "Fallow cultivation system and farmers resource management in Niger, West Africa" *Land Degradation and Development*, 13, 221-231, 2002.

[11] Zhi-gang, W., Xing-guo, B., Xiao-fei, Xin J., Jian-hua, Z., Jian-hao, S., Peter, C. and Long, L, "Intercropping maintains soil fertility in terms of chemical properties and enzyme activities on a timescale of one decade", *Plant and Soil*. 2015.

[12] Burke, K, "Origin of the Cameroon Line of Volcano-Capped Swells", *The Journal of Geology*, 109, 349-362, 2001.

[13] Yerima, B.P. K. and Van R.E, *Introduction to Soil Science: Soils of the Tropics*. Trafford Publishing Victoria BC Canada. ISBN: 1-41205853-8, 2005.

[14] Tematio, P., Kengni, L., Bitom, D., Hodson, M., Fopoussi, J.C., Leumbe, O., Mpakam, H.G., Tsozué, D., "Soils and their distribution on Bambouto volcanic mountain, West Cameroon highland, Central Africa", *Journal of African Earth Sciences*, 39, 447-457, 2004.

[15] Ngimdoh, M., Tchekote, H, and Achamoh, V. N. "Exploratory study on agricultural practices on the Bamboutos Mountains", *International Journal of Innovative Science and Research Technology*, 5(10), 2020.

[16] Stygerr, E. and Erick, C.M.F, *Contributions of managed fallows to soil fertility recovery*. The World Bank, Washington DC, USA, 2006.

[17] Kipot, E, "Adoption dynamics of Tithonia Diversifolia for soil fertility management in pilot villages of Western Kenya", Experimental Agriculture, 44, 473-484, 2008.

[18] Jama, B., Palm, C.A., Buresh, R.J., Niang, A, Gachengo, C., Nziguheba, G. and Amadalo, B, "Tithonia diversifolia as a green manure for soil fertility improvement in Western Kenya: A review". *Agroforestry Systems*, 49: 201-221, 2000.

[19] Mwangi, P.M and Mathenge, P.W. "Comparison of Tithonia (Tithonia diversifolia) green manure, poultry manure and inorganic sources of nitrogen in the growth of Kales (Brassicae pleraceae) in Nyeri county, Kenya", *African Journal of Food, Agriculture, Nutrition and Development*, 14(3), 8791-8808. 2014.

[20] Cairns, M. *Conceptualising indigeneous approaches to fallow management*. Road map to this volume, In: Voices from the forest: integrating indigenous knowledge into sustainable upland farming, Cairns, M., Ed., Johns Hopkins University Press, Baltimore, MD, 15-32, 2004.

[21] Tanveer, A., Ikram, R.M., Ali H.H, *Crop Rotation: Principles and Practices*. In: Hasanuzzaman M. (eds) Agronomic Crops. Springer, Singapore, 2019.

[22] Olabiyi, T.I, Harris, P.J.C., Atungwu, J.J. and Rosenfels, A. "Assessment of crop rotation and soil fertility building schemes in selected organic farms in England" *International Journal of Organic Agriculture Research and Development*, 1 (1), 38-51, 2010.

[23] Ifeyinwa, M. U., Arizechukwu, C. I., Chinyere, B. O. and Olubukola, O. B, "Legume-maize rotation effect on maize productivity and soil fertility parameters under selected agronomic practices in a sandy loam soil", *Scientific Reports*, 2019.

[24] Regehr, A., *Evaluation of maize and soya bean intercropping on soil quality and nitrogen transformations in the Argentine Pampa*. A thesis presented to the University of Waterloo for the degree of Master of Environmental Studies in Environmental and Resource Studies Waterloo, Ontario, Canada pp. 113, 2014.

[25] Odhiambo, J.J.O, and Nemadodzi, L.E, "Soil fertility management practices by smallholder farmers in Vhembe District Limpopo Province", *South African Journal of Agricultural Extension*, 36(1), 2007.

[26] Abubakar, A. S., Fondo, T. A., Nyong, P. A., "Agroforestry for sustainable agriculture in the Western Highlands of Cameroon" *Haya: The Saudi Journal of Life Sciences*, 5(9), 160-164, 2020.

[27] Awazi, N.P., and Tchamba, N.M, "Enhancing agricultural sustainability and productivity under changing climate conditions through improved agroforestry practices in smallholder farming systems in Sub-Saharan Africa", *African Journal of agricultural Research*, 14(7), 379-388, 2019.

[28] Misra, P.K., "Soil fertility management in Agroforestry System", *International Journal of Biotechnology and Biochemistry*. 7 (5), 637-644, 2011.

[29] Dollinger, J. and Shibu, J., "Agroforestry for soil health", *Agroforestry Systems*, 92, 213-219, 2018.

[30] Mbu, D. T., Nganje, S. N. and Chuo, J. N., "Intricacies of organic and chemical fertilizer application on arable land crop production in Cameroon", *Journal of Socioeconomics and Development*, 2(2) 61-72, 2019.

[31] Tolera, A., Tolcha, T., Tesfaye, M., Haji, K. and Buzuayehu, T. "Effect of Integrated Inorganic and Organic Fertilizers on Yield and Yield Components of Barley in Liben Jawi District", International *Journal of Agronomy*, 9, 1-7, 2018, Article ID 2973286, 7 pages.

[32] Ashraful, M. I., Sumiya, I., Ayasha, A., Md Habibur, R. D. N., "Effect of Organic and Inorganic Fertilizers on Soil Properties and the Growth, Yield and Quality of Tomato in Mymensingh, Bangladesh", *Agriculture*,7, 18, 2017.

[33] Woniala, J. and Nyombi, K., "Soil fertility management by smallholder farmers and the impact on soil chemical properties in Sironko District, Uganda", Research *Journal of Agriculture and Forestry Sciences*, 2(1), 5-10, 2014.