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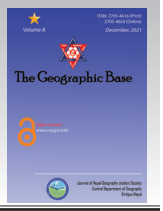

Soil Fertility Management Practice in Sainamaina Municipality, Rupandehi Nepal

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Article info

Keywords:
Soil fertility
Organic
Manure
Soil productivity
Local seed

Received: 5th Aug. 2021

Accepted: 23rd Nov. 2021

DOI: https://doi.org/10.3126/tgbv8i01.43475

Abstract

This paper aims to show the soil fertility management practice in Sainamaina Municipality, Rupandehi Nepal. Soil fertility management is human practice to increase crop productivity while maintaining or improving soil's physical chemical and biological properties. For research work, ward 5,6,7,8 and 9 of Sainamaina municipality Rupandehi district of Nepal was selected as the study area. This study was conducted based on both primary and secondary data. To make soil more fertile, urea, diammonium phosphate (DAP) and potas are applied as chemical fertilizer and animal dung and green manure (Sesbana bispinosa and vigna radiata) are used as organic fertilizer in the study area. To save potato from blight, farmers use to apply pesticides getting from local aggravates and pesticides are used to control Gabaro Stem Borer) in paddy and maize in spring and autumn. To remove weeds by human resource the Parimo System (equal labor sharing by farmers to each other) was rooted in past but through time Parimo System is decreasing because of peoples of study area are engaged to other occupation as well. Out of the

total agriculture area (2361.7ha) only 9% were irrigated. Around 80% area of the total irrigated land irrigated by public tub well. There are six tube wells situated in study area. Farmers of the study area used both domestic and improved seeds and they often practiced bartering system for local domestic seeds for their cultivation. Local domestic seed is gradually going to be replaced by hybrid seeds.

The different productivity of different crops was detected from the farmer as an indicator of soil fertility management practice.

Introduction

Soil fertility management is human practice to increase crop productivity while maintaining or improving soil's physical chemical and biological properties (Tripathi, 2019). Traditionally, soil fertility management is taken as economic return from crop production and main concentration is on expectation of large amount of crop production through adding nutrients on soil (Beegal et al., 2000). Along with improving soil qualities to get high quality appropriate management of soil and soil fertility should be adopted (Ogunjinmi et al., 2017). Soil fertility management is not only related to crop productivity improvement but also conservation of soil and water (Ouattara et al., 2017). Soil fertility management refers to practice of people to save soil fertility for sustainable agriculture.

For agricultural development, soil fertility management is very essential because soil fertility is not non-lasting matter of soil. Soil needs regular management for agricultural sustainability. Soil fertility management practice has three aspects; first, stabilizing remaining fertility, second, improving soil fertility status and utilizing soil fertility through crop production. Soil may become less fertile if we ignore its management. Various type of soil fertility management practice is needed for soil for example use of different fertilizers, crop rotation, terrace farming and irrigation. Individual farmer may also practice soil fertility management in his farm to improve productivity through indigenous way.

In Nepal, concept of soil fertility management is adopted from 9th development plan from government sector (Jaishay and Subedi, 2000). Untired hands of farmers and organic manure are mainly responsible for agricultural production in Nepal (Subedi, 2000). Understanding of fertility status of soil and proper nutrient management are necessary in order to get maximum productivity per unit area. For soil fertility improvement, use of farm yard manure and different green manure are in practice from long time in Nepalese agriculture. Easily decomposable vegetable waste is used as green manure *(chhapo*) in the past. *Asuro* (uslica adhaloda), *titepati* (Artemisia indica)), *khirro* (Wrightia arborea), *siris* (*albizialebbeck)*, *bakaino* (*meliaazaderach*), and *chilaune*

(*schimawallichii*) have been traditionally used as green manure or pesticide in Nepal. At present, *dhaincha* (*sesbina bispinosa*) is widely used as green manure in low land agriculture of Nepal. (IUCN, 2000)

Methods and Materials

Study area

This study covers the area of ward 5,6,7,8 and 9 of Sainamaina Municipality of Rupandehi district, Nepal. The geographical setting of the study area is 83°15'44" Eto 83°21'01" Elongitude, and 27°38'48" N to 27°46'05" N latitude. The elevation of study area ranges from 95 meter above sea level to 980 m. It has an area of 69 km^2 and total population of study area is 22456 (CBS, 2011). Climate in the study area is sub-tropical climate. The dominant soil types of the study area are Entisols and Inceptisols orders (KESL, 1986).

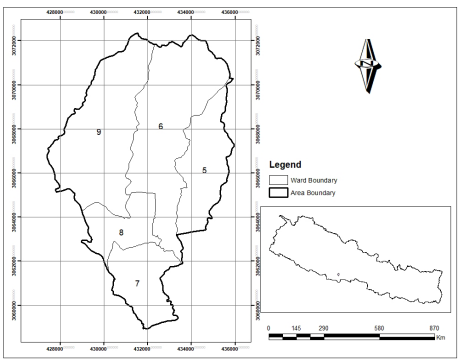

Figure 1. Study area

This study is conducted based on both primary data taken from field and secondary data collected from different secondary resources. Primary data is collected using questionnaire survey, key informant interview, and focus group discussion. Total 58 questionnaire survey (10 samples from ward 8 and 12-12 from ward no. 5,6,7 and 9) was conducted among farmers. The information about distribution of agricultural land among farmers and their practice of agricultural activities especially for soil fertility management, crop productivity, supports from government sector for soil fertility management, farmers' problem on soil fertility management and their expectation from governmental sector were asked using questionnaire survey among the farmers. Five key informant interviews were conducted with older farmer about history and system of agriculture practice for fertility management, changes appeared now in agricultural practice and what must have been done. Similarly, this KII was conducted among chair persons of wards and asked about effort, policy and achievement of local government on agriculture, special soil fertility management and soil productivity increasing. One focus group discussion among local people and local representative was conducted on soil fertility management practice by local people its effectiveness, changes in practice, supports from local and central government and their expectation from governmental sector for soil fertility management and.

Results and Discussion

Use of fertilizers

Soil, in itself is always not enough for sufficient crop yield. Some nutrients are inherent in soil and some must be added in farmland by farmers. For effective growth and development of plants and optimum production of crops both organic and inorganic fertilizers are source of mineral elements (Yagoub et al., 2012). Balanced application of fertilizer in farmland maintains crop quality, soil quality and increases crop yield (Yousaf et al., 2017). Application of fertilizers in farmland is needed according to requirement of specific crops and available nutrient status of soil. In the study area, farmers use different fertilizers. Urea, Dap and potas are the chemical fertilizers. Addionally farmers use animal dung and green manure (Sesbanabispinosa and vignaradiata) as organic fertilizer in study area.

Chemical fertilizer

In the study area, chemical fertilizers are applied in field to improve soil fertility. To make soil fertile, Urea, Diammonium Phosphate (DAP) and Potas are applied as chemical fertilizer in study area (Table 1). In the study area Urea is applied 90 kg/ha, DAP is applied 60 kg/ha and Potas is applied 30 kg/ha. For paddy, Diammonium Phosphate (DAP) is used once when planting it in mud and Urea is spplied twice first when removing weeds and second while flowering. For wheat Diammonium Phosphate (DAP) is used once, when planting. Urea is used twice, firstly, it is used during plantation, and secondly during flowering time. Farmer use to apply chemical fertilizer in their farmland in their own knowledge.

Table 1. Use of chemical fertilizer in study area by farmers

Used chemical fertilizer	Farmers (households)	Quantities
Urea (CH_4N_2O	58	90kg/ha
DAP (NH_4)	58	60kg/ha
Potas (P_2O_5)	15	30kg/ha

Source: Field Survey, 2019

Organic fertilizer

For most of the developing countries, organic agriculture and use of organic fertilizer is relatively new idea (Quynh and Kazuto, 2018). Use of organic materials like firm yard manure (FYM), crop straw and stalks and green manure is important step to save natural resources and stabilizing and optimizing soil quality (Shang et al., 2014).

Table 2. Organic fertilizers use

S. N.	Fertilizer	Type	Source	User Farmer %.
1.	Animal manure	Cow manure	Farmhouse	22
		Buffalo manure	Farmhouse	19
		Poultry manure	Poultry farm	34.5
2.	Green manure	Sesbinabispinosa (Dhaincha)	Private aggravate, agriculture cooperative and municipality agriculture section	13.5
		Vigna radiate (Mung Bean)	Farmhouse	11

Source: Field survey, 2019

Application of organic fertilizer in farmland is indigenous and traditional method of soil fertility management specially improvement. It contributes for soil nutrient improvement and makes soil easy to rooting for plants. Further it is easily made in village through decomposition of different materials.

Animal manure

Applying animal manure is old and traditional system of soil fertility management. Because of decreasing in livestock farming in households, availability and application of livestock manure is decreasing (Gbenou et al., 2017). Cow dung was applied as organic manure in farmland to increase soil fertility and productivity (Prapannacharya, 2015). In study area, cow, buffalo and poultry manure are used in farmland. After decomposing animal dung, farmers use it in their farmland and plow farmland and mix with soil. Farmers apply FYM before planting paddy. Livestock farming is decreasing day by day because of improvement of off farm activities. On the other hand, commercial livestock farming is increasing. Farmers use to apply FYM by buying from commercial poultry farming. In the study area 75.5% of total surveyed farmers use to apply animal manure in their farmland.

Green manure

Green manuring is age old agricultural practice. In China it dates back to more than 3000 years, records show that crops of green manure were grown and directly plowed or used as compost for of manuring of paddy farms (Allison, 1973). In study area, Sesbina Bispinosa (*Dhaincha*) & Mung bean are used as green manure.

Sesbina bispinosa (Dhaincha)

Sesbina Bispinosa is green manuring plant. *Sesbina bispinosa* is known as ideal green manure as it is quickly growing, easily decomposable and produces maximum amount of organic matter and nitrogen in soil (Palaniappan & Siddeswaran, 2001). As a green manure *sesbina bispinosa* plays role of nitrogen fixation, biomass production, soil structure improvement which are fundamental for plant growth (Rao and Gill, 1993). In the study area, use of *sesbina bispinosa* is practiced from long time as green manure by few farmers in their land. But at present time, the use of *sesbina bispinosa* is increasing. *Sesbina bispinosa* is used as green manure before planting paddy to decompose *sesbina bispinosa* sufficient water is needed. Due to warm temperature and sufficient amount of rainfall, it is growing rapidly in the study area. Agriculture office of Sainamaina municipality is providing seeds to the farmers. Farmers are also producing seeds themselves in village. Here in the study area 13.5% of total surveyed farmers use to apply *sesbina bispinosa* in their farmland for improving soil fertility.

Mung bean (Vigna Radiata)

Mung bean is the best green manure because of its short vegetation duration, high decomposability and capacity of nitrogen fixation (Dey and Jain, 2000). Mung bean (vigna Radiata) adds nutrients, organic matter and maintains moisture in soil (Bilkis et al., 2018). In study area, use of mung bean (*Vigna Radiata*) as green manure is new practice and is increasing day to day. It is planted in April and harvested in June. Then it is decomposed in mud before planting paddy. Farmers get double benefit from mung bean, first, lentils from its seeds, and second, green manure from its legumes. Here in the study area 11% of total surveyed farmers use to apply *Vigna Radiata* in their farmland for improving soil fertility. So, use of mung bean in their farmland for green manure is more common than *sesbina bispinosa* because it gives double benefits to farmers as lentils and green manure.

Use of pesticides

In modern agriculture, use of pesticide is a major input to control diseases and pest, which is increasing annually (Gyawali, 2018). There is not excessive use of pesticides in paddy, wheat, mustard, lentil, pea and flaxseeds. In winter, potato use to be infected from fungal infection named Blight. To save potato from blight, farmers use to apply pesticides getting from local aggravates. Pesticides are used in paddy and maize to control Stem borers *Gabaro (Stem Borer)* disease. Pesticides application is practiced as aggravate prescribes but intensity of pest and diseases are ignored because there is not proper junior technical assistant (JTA) to evaluate and analyze problem and recommend treatment. Rather, use of pest, disease and infection resistant seed will be better to become safe from harmful impact of pesticides. 31% of total surveyed farmers used to apply pesticides to save Paddy and maize from stem borer and 69% farmer use pesticides to save potato from blight.

Table 3. Use of pesticides

S.N.	Pesticides users	Crops	Diseases
1	31%	Paddy, Maize	Stem borer
2	69%	Potato	Blight

Weed management

Weeds are the most important biological constraints in agricultural systems which negatively affect crop growth and yield by competing with crops for nutrient, sunlight, space and water (Chauhan & Gill, 2014). Removal of unwanted weeds is very important practice of soil fertility management. To save 12% loss of total crop (Anaya, 1999) removal of unwanted weeds from farmland is very essential to utilize maximum amount soil fertility.

In the study area, 77.5% out of total 58 use to remove weeds from farmland with human resource/ man power, 8.5% farmers remove weeds using herbicides, and 14% farmers use to remove

unwanted weeds using both herbicides and human resources (Table. 3). In study area, there is not any practice of weed removal using mechanical equipment. But need of mechanical equipment for weed management in present age of agricultural modernization is realized in study area. In farmland, weeds are removed for paddy, wheat and maize. Weeds are removed from paddy field in August, in Janaury from wheat field and in April from maize. To remove weeds by human resource, the *parimo* system (equal labor sharing by farmers to each other) was rooted in past. At present *parimo* system is decreasing day by day because of people's engagement on off farm activities. Present days, paying for labor and use of herbicides are started to adopt to remove weeds. Generally, women are engaged in weed removing activity. Because of increasing Hill to Tarai migration land holding size per farmer are decreasing day to day. So, farmers remove weeds themselves due their small size farmland.

Table 4. Methods of weed management

S.N.	Methods of removing	Farmer (household)
1	Human labor	77.5%
2	Using herbicides	8.5%
4	Human labor and herbicides	14%
	Total	100%

Source: Field survey, 2019

Irrigation

Irrigation refers to process of applying of water to the soil (Bjorneberg, 2013), which is the most important for crop production. For appropriate supply of plant nutrient, which remains in soil, requires better irrigation facility. In study area, total agricultural area is 2361.7ha. Out of the total agriculture land only, 33.95 % areas have access of irrigation facility, in which 16% is irrigated by canal, 80% is irrigated by public tub well and only 4% is irrigated by private tube well (Table 4). There are 6 tube wells situated in the south of of East-West high way used to irrigate farmland in past but now those are not used.

Table 5. Irrigation status of study area

S. N.	Means of irrigation	Time	Irrigating area ha.	Irrigation area percent
1	Canal	Whole years	300	16
2	Tube well public	Whole years	500	80
3	Tube well Private	Whole years	2	4
4	No irrigation	Whole years	1559.7	
5	Unused tube well number		6	

Source: Field survey 2019

Use of seeds

Seeds quality is a relative term and can be defined as the degree of excellence as compared to an acceptable standard (Dobge et al., 2015). Seed quality is

complex and novel to improve crop production with the combination of seed technology for maximum utilization of soil fertility (Wimalasekera, 2015). Quality improved seed utilizes the maximum amounts of nutrient from soil. In the study area, both domestic and quality improved seeds are used.

Table 6. Seed types used in study area

S. N.	Use of seeds	Get from (source)	Households %
1	Quality improved seeds	Govt. office	6.5
		Cooperatives	26
		Private agr o-vet	53
2	Domestic seeds	farmer's own home	14.5
Total			58

Source: Field survey, 2019

Of the total surveyed farmers 14.5% farmers use local seeds. Local seed is available in farmer's own home. Local seed is stored by farmers in safe place after harvesting crops. In study area, there is bartering system for local seeds among farmers. Farmers use to exchange seeds with non-seed cereals before plantation. In study area, local seed is gradually going to be replaced by hybrid seeds. Half of the farmers use hybrid seeds. Among them, 6.5% farmers get seeds from government offices, 26.5% of them get seeds from cooperatives and remaining 53% farmers get seed from private agro-vet (Table. 5). Those farmers who use quality improved seeds, change seeds annually. In study area, quality improved seed is used for paddy, wheat, maize and pea.

Preparation of land for cropping

Preparation of farm land is very important component of soil fertility management. To make easy to absorb nutrient, to protect nutrient loss from the soil, to make easy way to pass plant roots, appropriate preparation of land in appropriate time is needed. There is no specific practice of farmland preparation for soil fertility management. Most of the farmers ploughs farmland by tractors before planning the crops and make water locking dams in autumns before planting paddy.

Productivity of land

Soil productivity is the ability of soil to support crop production. Agricultural productivity aggregates the performance of various crops in regard to their output from per unit area (Bhatia, 1967)

Table 7. Productivity status kg/ha. Of different crops

Crops types	Crops	N	Minimum productivity kg / ha.	Maximum productivity kg. /ha	Mean productivity kg. /ha	Std. deviation productivity kg / ha.
Cereal	Paddy	29	2900	8800	5459	1645.38
	Wheat	26	1180	3000	1957	561.72
	Maize	17	1500	2950	1679	713.1
Pulse	Lentil	12	900	3100	1602	293.23
	Pea	13	1500	4500	1877	989.18
Vegetable	Potato	12	2350	9000	4314	1641.9
Oilseed	Mustard	11	1750	4450	2930	680.4
	Flaxseed	12	880	1760	1270	502.86

Source: Field survey, 2019

Crop productivity is important indicator of soil fertility and its management in farmland. Crop productivity represents, how the soil fertility is managed in particular farmland. Changing soil fertility management practice and fertility status changes the crop productivity of land. In the study area, different productivity of different crops was observed. Paddy, wheat, mustard, lentil, pea potato and maize were chosen to study the productivity status of soil in study area (Table 6.).

Problems on soil fertility management

Management of soil fertility is not a single dimensional task. It is very complex and sensitive work. It is not so easy to manage soil fertility. There come so many problems and obstacles while managing soil fertility.

Table 8. Problems on soil fertility management and crop production

S. N.	Problems	Priority		
		Priorty 1	Priority 2	Priority 3
1	Lack of irrigation	36	12	10
2	Lack of JTA services	26	20	12
3	Diseases'	31	16	11
4	Unavailability of chemical fertilizer in time	25	13	20
5	Unavailability of improved seeds in time	32	15	11
6	Lack of sufficient human labor	58		
7	Crop destruction by wildlife	21	14	23

Source: Field survey, 2019

In the study area, various problems regarding soil fertility management are found. Every problem has different degrees for different farmers. Same

problem is perceived differently by different farmer because different farmers have different coping capacity for each problem. In spite of having their willing to better production, because of various problems in various degrees farmers are not able to produce enough crops as they can. The major problems on soil fertility management perceived by farmers are, lack of irrigation, lack of JTA services, disease, unavailability of chemical fertilizer in time, unavailability of improved seed in time, lack of sufficient human resource and crop destruction by wild animal. All the above-mentioned problems are perceived differently (Table 7.).

Conclusion

As soil is non-renewable and having long forming time natural resource, it is essential to protect and manage its fertility. Soil fertility management is very essential for proper utilization of soil and to take optimum benefit from soil through agriculture. In study area, most of people engaged in agriculture and practicing for soil fertility management. To improve soil fertility status farmer, use chemical and organic fertilizer. Urea, DAP and Potas are used as chemical fertilizer and Animal dung and Green manure *(sesbinabespinosa* and mung bean) are used as organic fertilizer. In the context of decreasing livestock farming, application of green manure in farmland as organic fertilizer is needed. Use of disease, pest and infection resistant seeds must be chosen rather than using pesticides. Proper guidance of expert JTA for application of chemical fertilizer and pesticides is needed. For optimum productivity of soil, most of the farmers use to remove invasive weeds from farmland by human labor followed by use of herbicides. Out of the total agricultural land, only one third portion is irrigable. There are great requirements of repairing and reuse of unused tube wells to irrigate large parts of agricultural land. Out of total irrigable land, most of the land is irrigated by public tube well followed by canal and private tube well. There is demand of irrigation system by farmers for agricultural sustainability. In spite of using domestic seeds, application of hybrid seed is required to increase crop yield.

References

Allison, F.E. (1973). *Soi*l organic matter and its role in crop production. New York: Elsevier Scientific Publishing Company

Anaya, A.L. (1999). Allelopathy as a tool in the management of biotic resources. *Critical Reviews in Plant Sciences*, 19: 697-739

Beegle, D. B., Carton, O. T., & Bailey, J. S. (2000). Nutrient management planning: justification, theory, practice. *Journal of environmental quality* 29:72-79

Bhatia, S.S. (1967). A new approach to measure agricultural efficiency in Uttar Pradesh. *Economics Geography*, 43, 224-260

Bilkis, S., Islam, M. R., Jahiruddim, M., Rahaman, M. M., & Hoque, T. S. (2018). Residual effects of different manures and fertilizers applied to preceding potato crop on succeeding mung bean (Vigna Radiate L.) crop in potato-mung bean-rice cropping pattern. *SAARC J. Agri*., 16(2): 167-179 DOI: https://doi.org/10.3329/sja.v16i2.40268.

Bjorneberg, D.L. (2013). Irrigation methods, reference module in earth systems and Environmental Sciences, *Elsevier*. doi: 10.1016/B978-0-12-409548-9.05195-2 s

CBS. (2011). *National Population Census (2011)*. Kathmandu: Central Bureau of Statistics

Chauhan, B.S., & Gill, G.S. (2014). Ecologically based weed management strategies. *Recent Advances in Weed Management*. DOI 10.1007/978-1-4939-1019-9 *Springer,* New York Heidelberg Dordrecht London

Dey, P., & Jain, J.M. (2000). Evaluation of urea enriched green manures for their efficiency to sustain productivity of rice-wheat system. *Indian Soc. Soil Sci*., 48: 102-107.

Dogbe, W., Dzomeku, I.K., Yahaya, B. S., Siise, A., Krofa, E. O., & Awuakye, S.A. (2015). Influence of seed quality and soil fertility management on the productivity of rice (oryza sativa l.) in the guinea savanna of ghanauds. *International Journal of Development [UDSIJD]* 2:2, 15-25. http://www.udsijd.org.

Gyawali, K. (2018). Pesticide uses and its effects on public health and environment. *Journal of Health Promotion*, 6, 28-36

Gbenou, B., Adjolohoun, S., Ahoton L., Houndjo, D. B. M., Saidou, A., Houinato, M., & Sinsin, B. A. (2017). Animal dung availability and their fertilizer values in a context of low soil fertility conditions for forage seed and crops production in Benin (West Africa) *Journal of Agri)*. American cultural Research, 2(12): 1-14.

IUCN Nepal. (2000). *National register of medicinal plants*. Kathmandu: IUCN Nepal.

Jaishy, S. N. (2000). Current fertility status of Nepal Components of integrated plant nutrient management for Nepal Kathmandu.

Jaishi, S.N., & Subedi T.B. (2000). Procedure for soil sampling and analysis: Component of integrated plant nutrient management for Nepal. Proceedings of a Workshop at the Department of Agriculture. Harihar Bhawan, Lalitpur, 11-17 Falgun 2056 (23-29 February 2000).

KESL. (1986). *Land system map. Land resource mapping project,* Kathmandu: Survey Department Nepal.

Ogunjinmi, O. F., Kolawole G. O., & Oyeyiola Y. B. (2017). Soil fertility assessment and determination of potential ameliorants for an alfisol under long-term continuous cultivation in southwestern Nigeria. *Journal of Soil Science and Environmental Management*.

8(9):155-163. DOI: 10.5897/JSSEM2017.0649.

Outtara, K., Serme, I., Bongoungou, S., & Zombre, P. (2017). Soil and water conservation, and soil fertility management effects on rain water productivity of maize hybrid in Burkina Faso. *African journal of agricultural research*, 12(12), 1014-1021. DOI: 10.5897/AJAR2016.11976

Palaniappan, S. P., & Siddeswaran, K. (2001). Regional overview on green manure in ricebased cropping systems. In: Gowda, C.L.L., Ramakrishna, A., Rupela, O. P. and Wani, S. P. (eds). Legumes in rice based cropping systems in Tropical Asia: constraints and opportunities. International Crop Research Institute for Semi-Arid Tropics, Patancheru, India, 126-135.

Prapnnnacharya, S. (2015) Vedma Ke Chha ed. "What is in ved" Kathmandu: Sajhaprakashan

Quyhn, H.T., & Kazuto, S. (2018). "Organic fertilizers" in Vietnam's markets: Nutrient composition and efficacy of their application. *Sustainability* 2018, 10, 2437;doi:10.3390/su10072437,www.mdpi.comjournal/ sustainability

Rao, D. L. N., & Gill, H. S. (1993). Nitrogen fixation, biomass production, and nutrient uptake by annual Sesbania species in an alkaline soil. Biology and Fertility of Soil, 15:73-78. https://www.researchgate.net/publication/225894131

Shang, Q., Ling, N., X. Feng., & Zou, J. (2014). Soil fertility and its significance to crop productivity and sustainability in typical agro-ecosystem: a summary of long-term fertilizer experiments in China. *Plant Soil*, 381:13–23. DOI 10.1007/s11104-014-2089-6

Subedi, P. (2000). Nutrient availability and nutrient use efficiency: Basic concepts for plant nutrient management. Component of integrated plant nutrient management for Nepal. Proceedings of a Workshop at the Department of Agriculture. Harihar Bhawan, Lalitpur, 11-17

Tripati, B. P. (2019). Sustainable soil fertility management practice in Nepal. Kathmandu: Acta Scientific Agriculture, 3(4):112-113.

Wimalasekera, R. (2015). Role of seed quality in improving crop yields. Crop Production and Global Environmental Issues, 153-168.

Yagoub, S. O., Wigdan, M. A. A., & Mariod, A. A. (2012). Effect of urea, NPK and compost on growth and yield of soybean (Glycine max L.), in semi-arid region of Sudan. International Scholarly Research Network ISRN Agronomy. 2012 DOI:10.5402/2012/678124

Yousaf, M., Jifu, L., Jianwey, L., Tao, R., Rihuan, C., Shah, F., & Xiaokun, L. (2017). Effects of fertilization on crop production and nutrient-supplying capacity under rice-oilseed rape rotation system. *Scientific reports*. DOI:10.1038/s41598-017-01412-0