STRENGTHENING AGRO-ECOSYSTEMS RESILIENCE FOR CLIMATE CHANGE ADAPTATION TO IMPROVE FOOD AND NUTRITION SECURITY (TCP/NEP/3701)

SOIL MICRO-ORGANISM REPORT

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1. INTRODUCTION

Intensification of agriculture has resulted overall deterioration in soil-based ecosystem making soil poor reserve of micro-organisms, nutrients and organic matter leading to loss of biodiversity, thereby damaging sustainability of agricultural production, soil resilience capacity, and environmental quality. The capacity of the soil system to supply nutrients and retain applied nutrients is undermined by practices that diminish the role of soil organisms and lead to depletion in soil organic matter. In general, plants serve as carbon source for the microbial community and in turn microbes provide nutrients for growth through mineralization of plant and animal residues, and organic matter, thus soil microbial biomass is a significant parameter to draw an inference about the soil health (Dwivedi and Soni, 2011). Therefore, appropriate application of targeted, sufficient, and balanced quantities of soil nutrients and soil management is necessary to make nutrients available for high yields of crops without polluting the environment.

Soil being reservoir of life is a rich source of microorganisms responsible for its most important functions in terrestrial ecosystems. Interaction between edaphic microorganisms and plants usually determines the biodiversity of vegetation. The level of soil microbial biomass and the activity of top soil organisms are important factor in determining soil health, and soil microbial biomass has been used as an index of soil fertility. Microbial communities may also be used as parameters of soil health because the ecological equilibrium between pathogens and biocontrol agents naturally suppresses the incidence of diseases. Some of the microorganisms available in the soil are very beneficial for the agriculture which are discussed below:-

Trichoderma

Trichoderma refers to the genus of fungi, which mostly have a mutualistic relationship with plants, which typically grow fast at 25°-30°C but can grow well up to 45°C. *Trichoderma* spp. have been used as biocontrol agents due to their specific mechanisms, like antibiosis, parasitism, host-plant resistance and competition, and they have now been popular both as biofertilizer and biopesticide. *Trichoderma* spp. play importance roles in growth, yield and nutritional quality of various crops (Molla et al., 2012; Saravanakumar et al., 2017). *Trichoderma*, being a fungus, affects positively or negatively to higher plants. It is highly interactive in root, soil and foliar environments. It reduces growth, survival or infections caused by pathogens by its different mechanisms, like competition, antibiosis, mycoparasitism, hyphal interactions and enzyme secretion.

Azotobacter

Azotobacter spp. are the free living bacteria, which grow well on a nitrogen free medium. These bacteria utilize atmospheric nitrogen gas for their cell protein synthesis. They are ubiquitous and abundantly found in neutral to weakly acidic soils. In dry soils, *Azotobacter* can survive in the form of cysts for up to 24 years. *Azotobacter* enhanced biofertilizer plays significant role in plant growth (Wani et al., 2016).

Actinomycetes

Actinomycetes are aerobic spore forming gram-positive bacteria. They are the most abundant organisms that form thread-like filaments in the soil and are responsible for characteristically “earthy” smell of freshly turned healthy soil. They play major roles in the cycling of organic matter; inhibit the growth of several plant pathogens in the rhizosphere and decompose complex mixtures of polymer in dead plant, animal and fungal material results in production of many extracellular enzymes which are conductive to crop production. The major contribution in biological buffering of soils, biological control of soil environments by nitrogen fixation and degradation of high molecular weight compounds like hydrocarbons in the polluted soils are remarkable characteristics of *Actinomycetes*. Besides this, they are known to improve the availability of nutrients, minerals, enhance the production of metabolites and promote plant growth regulators. They decompose the more resistant and un-decomposable organic substance/matter and produce a number of dark black to brown pigments, which contribute to the dark color of soil humus. They are also responsible for subsequent further decomposition of humus (resistant material) in soil. Therefore, first and foremost step is the soil analysis to determine their present status and initiate necessary actions for healthy soil formation and beneficial micro-organism conservation.

Table 1. Microorganisms supporting in ecosystem services

Ecosystem services	**Microorganisms providing the services**
Organic matter decomposition and cycling	Bacteria, actinomycetes, fungi, especially belonging to cellulolytic group (e.g. species from genera *Cytophaga*, *Chaetomium*, *Mortierella*, *Epicoccum*).
Improving nutrients availability and uptake	Majority of bacteria, actinomycetes (nitrogen mineralizing species of Streptomyces from Series Griseus), microfungi, ecto or endo-mycorrhizal fungi forming symbioses with trees (e.g. basidiomycetes).
Suppression (inhibition) of plant pathogens	Antagonistic species of bacteria (e.g. *Pseudomonas fluorescens)*, actinomycetes, fungi (e.g. *Trichoderma viride, Paecilomyces* sp.)
Plant growth control	Plant growth promoting microorganisms, mycorrhizal fungi, biocontrol agents (antagonists for pathogens).
Improving soil structure and hydrological processes	Bacteria producing exopolysaccharides (pseudomonads), actinomycetes, fungi, (e.g. species from genera *Humicola*, *Trichoderma,* *Myrothecium*, *Cladosporium*), mycorrhizal fungi, all contributing to formation of soil aggregates.
Regulation sequestration of gas exchange and carbon	Microorganisms from all groups, mostly from cellulolytic group

Source: Matei et al., 2020.

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2. OBJECTIVES

- To determine the status of micro-organisms on soil samples in the project sites in Dang, Gulmi & Mustang.
- To make aware the farmers on the importance of soil micro-organisms for crop production.
- To recommend suitable management measures to maintain micro-organisms and soil fertility and sustaining crop productivity.

3. METHODOLOGY

Sampling is the vital step for soil micro-organism analysis, which were collected following soil testing standards from farmers' fields as representatives of the selected areas. Altogether 30 soil samples were collected from the project districts Dang, Gulmi and Mustang. Ten fields were selected from each districts representing all the project sites randomly. In the Dang district, the soil sampling was carried out before the cultivation of the Maize and before the manuring on the Citrus in Gulmi and Apple fields, Mustang in the month of January-February 2020. For this, surface litter was scraped away without disturbing soil, V-shaped cut up to 15 cm depth, and soil slices collected in plastic bucket moving in a zig-zag manner from each sampling unit in the case of the Maize whereas in Citrus and Apple soil sample were taken from the three layers i.e 0-15 cm, 15-30 and 30-60 cm. Five soil samples were collected from homogenous sampling units, mixed them thoroughly, which were divided into four units and two opposite units were selected each time so that the final composite sample of 400 gm (one sampling unit) was selected. Thus collected samples kept in plastic bags, well labeled, brought in Laboratory for analysis.

The plate-count technique (modified dilution-plate method as described by Johnson and Curl (1972) was used for determining numbers of *Trichoderma*, *Azotobacter* and *Actinomycetes*. Briefly, the soil was shaken in a sterile flask and suspensions prepared. Plate of a specific medium for each microorganism was prepared. To study the microorganism present in the soil, the suspension was diluted to 10^{-4}. These petri plates were incubated in an inverted condition for three to five days at 30◦C for fungi and 37◦C for bacteria, *Azotobacter* and *Actinomycetes* colony formation. After incubation, colonies were counted.

4. RESULTS

Farmers knowledge on the microorganism

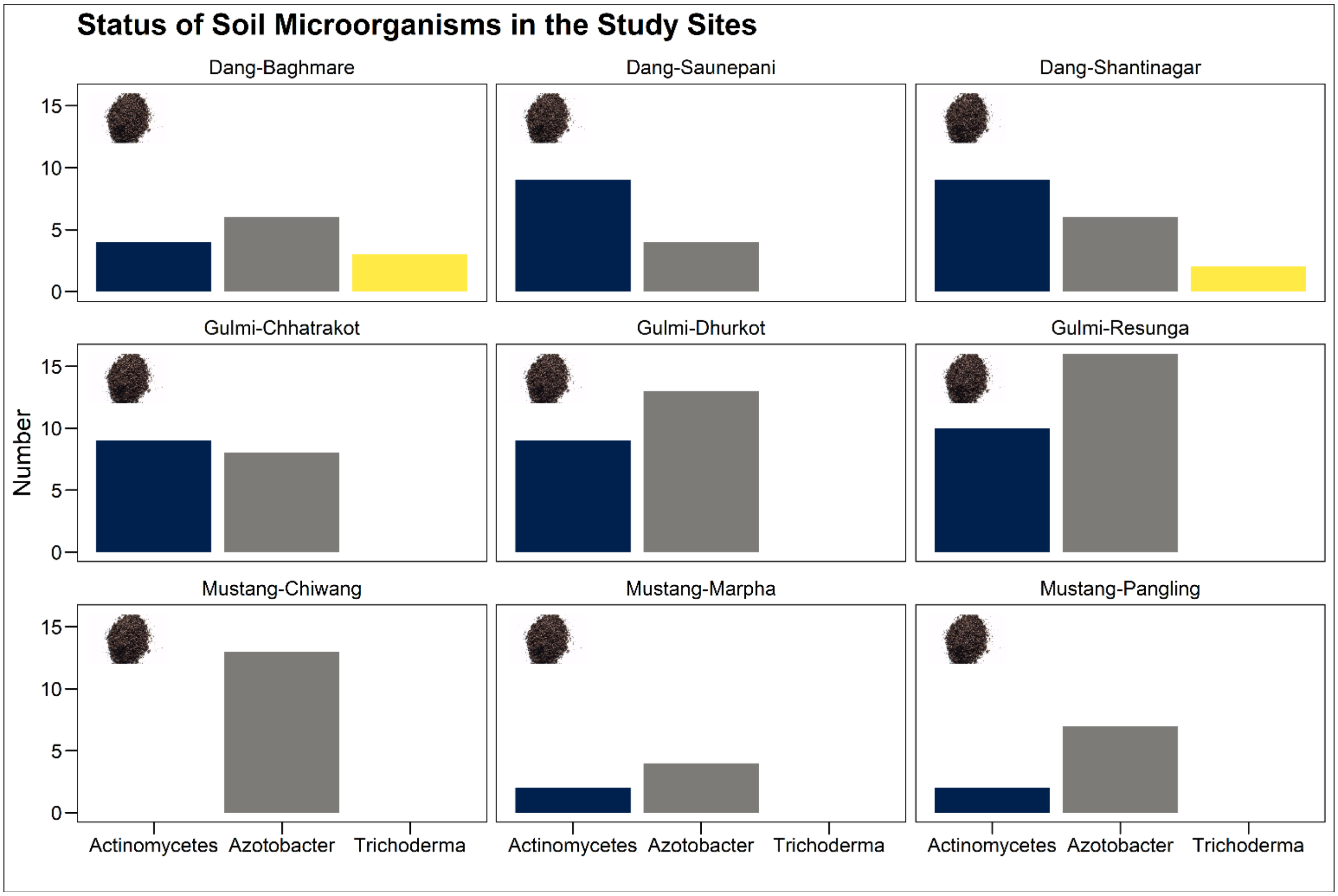
The farmers survey revealed that overall more than 80% of the farmers are unknown about the soil beneficial microorganism. The farmers from the Gulmi and Mustang didn't have any knowledge on the soil microorganism as shown in Table 2.

Table2. Farmers knowledge on the soil microorganism in the project districts.

S.N	Knowledge on soil microorganism	Dang	Gulmi	Mustang	Total	P value
1.	Yes	55 (46.2%)	0 (0.0%)	0 (0.0%)	55 (18.8%)	< 0.001
2.	No	64 (53.8%)	114 (100.0%)	60 (100.0%)	238 (81.2%)	

Status of Soil microorganisms in the project sites

Figure 1 presents the status of the soil micro-organism in the project sites.



The figures shows, three microorganisms *Actionomycetes*, *Azotobacter* and *Trichoderma* were presented in the soil sample taken from the two project sites Baghmare and Shantinagar whereas *Trichoderma* population was nill in Saunpani sites of the Dang districts. Similarly, *Actinomycetes* and *Azotobacter* were found in three sites Chatrakot, Dhurkot and Resunga of Gulmi whereas there was no population of the *Trichoderma* found. In case of Mustang, *Azotobacter* was found in the three sites whereas *Actinomycetes* was found in Marpha and Pangling. The *Trichoderma* population was also found Nil in all the project sites of Mustang.

Status of Soil microorganisms in the project districts

The status of the soil microorganisms were shown in table 2. We found that the *Trichoderma* microorganism population was not traced in the 10^{-4} diluted solution in the two districts as shown in table 2. In Dang, out of 10 samples analyzed it occurred only in 4 samples in the 10^{-4} diluted solution (refer appendix). It ranged from 0 to 3 with an average of 0.80 cfu/g of soil.

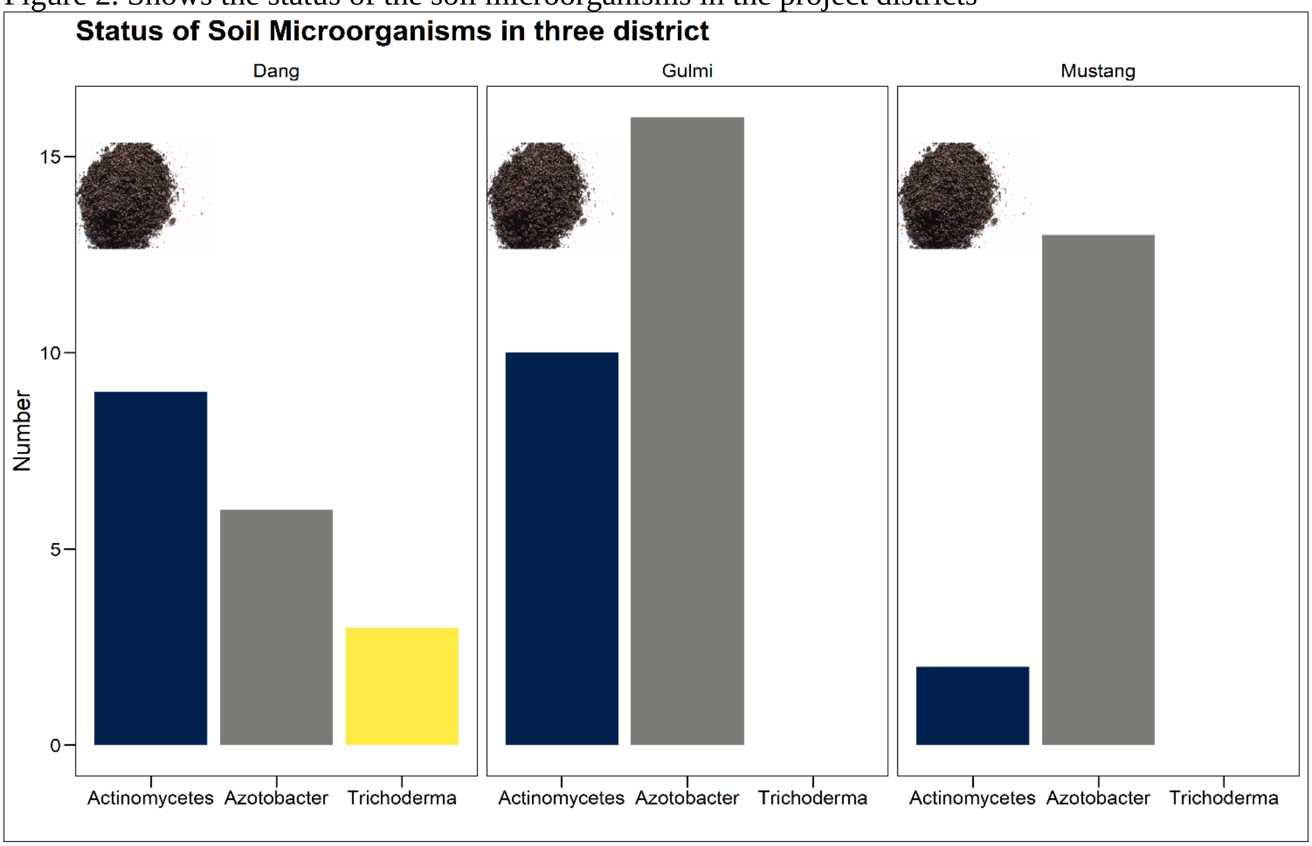
Table 2. Soil microorganisms *Trichoderma, Azotobacter and Actinomycetes* (cfu/g) of soil in sample analysis of from Dang, Gulmi and Mustang districts

SN	Statistical value	Trichoderma	Azotobacter	Actinomycetes
1	Dang	0.8 (1.14)	3.7 (2.16)	3.8 (3.12)
2	Gulmi	-	8 (4.50)	5.6 (2.67)
3	Mustang	-	5.5 (4.22)	0.4 (0.84)

*Figures in the parentheses indicated the standard deviation.

The soil microorganism, *Azotobacter* occurred in 90% of the samples in all selected districts (refer appendix) - Dang, Gulmi and Mustang (Table 2). The count was the highest in soil samples from Gulmi with mean of 8.0 (range 0-16) followed by Mustang with mean of 5.5 (range 0-13) and Dang with mean of 3.7 (range 0-6) cfu/g of soil, respectively. The soil micro-organism *Actinomycetes* also occurred in all 10 samples in Gulmi, 8 samples in Dang and only in 2 out of 10 samples in Mustang district (refer appendix). Mid hill (Gulmi) soil represented high count (mean 5.6 and range 3-10), followed by Dang (mean 3.8 and range 0-9) and Mustang (mean 0.4 and range 0-2) *Actinomycetes* cfu/g of soil, respectively.

Figure 2. Shows the status of the soil microorganisms in the project districts



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MANAGEMENT STRATEGY

Soil is considered as a complex and dynamic biological system that provides diverse habitats for the microbial community and is a hotspot for belowground microbial interactions. Table 3 shows the presence of number and biomass of microbial species at upper depth of soil. The soil microbial community acts as a central factor in mediating the key ecosystem services and functions. Only a small fraction of soil microorganisms have been cultured and studied because only about 1% of microbes are culturable, the uncultured microbiota is considered as a treasure trove of the microbial world. Therefore, exploring this hidden resource is important, especially for agriculture.

Table 3. Relative numbers and biomass of microbial species at 0–15-cm depth of soil

SN	Microorganisms	Number per gm of soil	Biomass (g/m^2)
1	Bacteria	10^8–10^9	40–500
2	Actinomycetes	10^7–10^8	40–500
3	Fungi	10^5–10^6	100–1500
4	Algae	10^4–10^5	1–50

Source: Adu and Oades, 1978.

The soil microbial population consisting of bacteria, fungi and micro-fauna (microscopic) are termed as soil microbial biomass (SMB). The soil biota includes vast numbers of microorganisms that naturally reside in soil and perform a wide range of functions which are essential for a normal and healthy soil. Total carbon and soil microbial biomass present in different land use system are shown in table 4. Data presented reveals the relationship between the SOC with SMB, which shows that the conversion of forests and pasture lands into other land uses has resulted in remarkable decline in the amounts of soil nutrients and soil microbial biomass. While, global averages for SMB-C are 700, 1090, 850 for cultivated, grassland and forest soils, respectively, which range from 110 kg- C/ ha in a cultivated field with total C of 0.7% to 2240 kg- C/ha in a grassland soil with total C 7.0% (Smith and Paul, 1990). For SMB-N the values are 195, 225 and 170 for cultivated, grassland and forest soils, respectively.

Table 4. Soil microbial biomass in different land uses and plantations

SN	Land use/plantation	Total C (%)	Microbial biomass (μg g^{-1} of soil)
1	Crop field	1.06	250.00
2	Pasture	2.53	659.00
3	Mixed grass	0.37	49.95
4	Savanna	1.20	397.00
5	Forest	2.18	609.00
6	Mine spoil	NA*	332.00
7	*Acasia*	0.51	104.64
8	*Vetiveria*	0.58	135.14
9	*Desmostachya*	0.71	195.25
10	Pine forest	0.53	121.00

Source: Dwivedi, and Soni, 2011

The soil microbial biomass influences the availability of amount of the carbon and other nutrients importantly N and P for plants. Data presented in Table 5 shows that importantly play role in N fixation, Phosphorous and Potash solubilization, Iron reduction and their availability to different crop species through their various mechanisms.

Table 5. Microbial traits that enhance nutrient uptake by plants

SN	Microorganism	Crop species	Nutrient	Mechanism
1	*Rhizobium* spp.	*Phaseolus vulgaris*	N	Symbiotic nitrogen fixation
2	*Bradyrhizobium japonicum*	*Glycine max*	N	Symbiotic nitrogen fixation
3	*Frankia* spp.	*Discaria trinervis*	N	Symbiotic nitrogen fixation
4	*Frankia* spp.	*Casuarina* spp	N	Symbiotic nitrogen fixation
5	*Azospirillum brasilense*	*Oryza sativa*	N	Non-symbiotic nitrogen fixation
6	*Azospirillum. brasilense*	*Triticum aestivum*	N	Non-symbiotic nitrogen fixation
7	*Azotobacter* spp.	*Heliantus tuberosus*	N	
8	*Herbaspirillum* spp. and *Burkholderia vietaminensis*	*Oryza sativa*	N & P	Phosphorous solubilization; and promotion of N use efficiency
9	*Bradyrhizobium*	*Ipomoea batatas*	N	Non-symbiotic nitrogen fixation
10	*Pseudomonas putida*	*Hordeum vulgare*	P	Phosphorous solubilization by acidification
11	*Sinorhizobium meliloti*	*Medicago truncatula*	P	Phosphorous solubilization by acidification and phosphatase activity
12	*Piriformospora indica*	*Zea mays*	P	Phosphate transport
13	*Bacillus mucilaginosus*	*Sorgum vulgare*, *T. aestivum* and *Z. mays*	K	Potassium solubilization
14	*Arthrobacter agilis* UMCV2	*Phaseolus vulgaris*	Fe	Iron reduction/ solubilization
15	*Arthrobacter agilis* UMCV2	*Medicago truncatula*	Fe	Plant strategy I induction

Source: Gupta et al. (eds.). 2016.

The soil enzymes are known to function in both nutrient cycling and soil organic matter decomposition (Table 6), which are also equally important in plant nutrient utilization by plants and management in soil fertility. Some of the alkaloids produced by the micro-organisms, such as fungal endophytes also are effective against different crop insect pests- aphids, fall armyworm, flies and weevils (Table 7).

Table 6. Some important soil enzymes and their functions in both nutrient cycling and soil organic matter decomposition

SN	Enzyme	Substrate	Enzyme reaction	Significance of enzyme
	Nutrient cycling			

1	Amidase	Carbon and nitrogen compounds	N-mineralization	Plant available NH4+
2	Phosphatase	Phosphorous	Release of PO43+	Plant available P
3	Sulphatase	Sulphur	Release of SO42-	Plant available S
4	Urease	Nitrogen	Release of NH3 & CO2	Plant available NH4+
	Decomposition of organic matter			
5	β-glucosidase	Carbon compounds	Cellulose hydrolysis	Energy for microorganisms
6	Fluorescein diacetate (FDA) hydrolysis	Organic matter	Carbon and various nutrients	Energy for microorganisms as measure of microbial biomass

Source: Yang et al., 2015.

Table 7. Alkaloids produced by fungal endophytes against insects

SN	Endophytic fungi	Alkaloids	Effective to insect pests
1	*Balansiae cyperi*	Agroclavine	*Spodoptera frugiperda*
2	*Neotyphodium coenophialium*	Pyrrolopyrazine	Argentine stem weevil
3	*Acremonium coenophialum, Epichloe typhina*	Loline, peramine	Aphids
4	*Nodulisporium* sp.	Nodulisporic acid A	*Aedes* mosquito, blowfly

Source: Gupta et al. (eds.). 2016.

Compost manuring, such as use of FYM/Poultry manure Vermi-compost is always beneficial to plants and soils in many aspects. This has been exemplified with the use of Vermi-compost and comparing with chemical fertilizers (Table 8). Vermi-compost application supersedes chemical fertilizer in all aspects, i.e. availability of NPK, carbon biomass and soil micro-organisms.

Table 8. Farm soil properties under vermi-compost and chemical fertilizer

SN	Chemical and biological properties of soil	Vermi-compost	Chemical fertilizers
1.	Availability of nitrogen (kg/ha)	256.0	185.0
2.	Availability of phosphorus (kg/ha)	50.5	28.5
3.	Availability of potash (kg/ha)	489.5	426.5
4.	Azatobacter (1000/gm of soil)	11.7	0.8
5.	Phospho-bacteria (100,000/kg of soil)	8.8	3.2
6.	Carbonic biomass (mg/kg of soil)	273.0	217.0

Source: Suhane, 2007.

Bio-fertilizers, like *Rhizobium*, *Azotobacter* and *Azospirillium* because of their beneficial nature to plants and soils have been produced commercially and used by the farmers in different crops as seed and soil treatments (Table 9

Table 9. Some beneficial organisms used as bio-fertilizers in vegetables

SN	Organism	Mode of action	Use in crops	Method of treatment	Dose (g/ha)
1.	Rhizobium	Symbiotic N fixation	Leguminous vegetables	Seed treatment	600
2.	Azotobacter	Asymbiotic N fixation	Vegetables	Seed treatment	3,400
3.	Azospirillum	Asymbiotic N fixation	Vegetables	Seed treatment Soil application	1,000 2,000
4.	PSM	Phosphorus solubilization	Vegetables	Seed treatment	600

Source: Chaudhari et al., 2014.

Recommendations

- Realizing the results of sample analysis, in three different agro-climatic conditions in Dang, Gulmi and Mustang districts, it becomes obvious to know the real field and crop situation by frequently visiting crop fields, sampling and monitoring plants, plant growth and vigor, crop yield and quality, identifying presence of microorganisms and cause of nutrient imbalances in soil and plants, and recommended best eco-friendly practices for higher crop productivity with long-term sustaining of soil productivity. Three is a need of restoration of soil microbial properties.
- Food grain production increased with time and problems of number of elements deficient in soils also increased from 1 (N) in 1950 to 9 (N, P, K, S, B, Cu, Fe, Mn, and Zn) in 2005–2006 in crop production (Shukla et al. 2014). So, no single soil property is sufficient to evaluate the effect of anthropogenic or natural impacts on an ecosystem, because all methods are subjected to limitations. Emphasis should be given to soil organic carbon content by keeping its importance in microbial management as given in Table 15.

Table 10. Soil problems and their management

SN	Soil problems	Management strategies
1	Low water holding capacity	Use zeolites, biosolids, and soil conditioners
2	Low soil fertility	Use nano-enhanced slow-release fertilizers, integrated nutrient management, and precision farming
3	High susceptibility to erosion	Provide continuous soil cover, use no-till and mulch farming with cover crops, establish contour hedges with perennials
4	Vulnerability to compaction	Avoid heavy traffic when soil is wet, use guided traffic, promote soil fauna (earthworms)
5	Low soil organic matter content	Recycle biosolids, use forages and deep-rooted cover crops, apply biochar, minimize tillage, control erosion
6	Low use efficiency of inputs	Deliver water and nutrients directly to plant roots and eliminate losses

7	Low productivity	Combine high tech varieties with innovative management options
8	Susceptibility to biotic and abiotic stress	Develop varieties that emit molecular-based signals detectable through remote sensing followed by targeted intervention

Source: Lal and Stewart (eds.), 2010.

- Chemical nutrient needs to be used only on soil test-based recommendations in optimum quantities with balanced use of fertilizers, including organic matter application, green manuring and cropping systems practices.
- The balanced application of NPK (100% or 150% NPK) showed higher accumulation of soil organic C- over imbalanced use of fertilizers (100% N and 100% NP) in different cropping systems (maize-wheat-cowpea, rice-wheat-jute, maize-wheat, soybean-wheat) over three decades under dissimilar climate and soil. Long-term effect of manuring and fertilization under various rice-based cropping systems on C buildup in some Inceptisols and reported that total soil organic C (0–0.20 m) was highest in the NPK + FYM (38.8 Mg C ha-1) followed by NPK (35.2 Mg C ha-1) > fallow (33.1 Mg C ha-1) and control (28.2 Mg C ha-1) treatments.
- Improved timing and/or splitting of fertilizer N increased N recovery efficiency from 0.17 kg kg-1 in FFP plots to 0.27 kg kg-1 in Site Specific Nutrient Management plots with 63% greater agronomic N use efficiency compared to Farmer Field Practice (Khurana et al., 2008).
- Liming has been useful to decreases losses of nutrients and metals in surface run-off by increasing soil holding capacity for these elements. Reactive P leaching loss was reduced by 36%, 17.5% and 40.4%, respectively, by amendment of CaCl2, CaCO3 or CaCl2 + CaCO3, as compared to chemical fertilizer application alone.
- Incorporation of vegetative residue into the soil instead of burning them is also important to reduce nutrient leaching. While selecting fertilizers also, use of slow release fertilizer is an important approach to reduce nutrient leaching.
- Inoculation with Rhizobium culture to legume crops increase grain yields- 10-36% in cowpea, 3-26% in lentil, 4-67% in chickpea and 3-50% in pigeonpea. Use of blue green algae which usually can fix 25-30 kg N/ha per cropping season. For example, for rice cultivation azolla is applied as green manure both by basal application and as top dressing and under optimum conditions an azola crop may produce 3 kg or more N/ha/day.
- Real worth of carbon in soil organic matter is needed to understand the societal value of carbon vis-à-vis the day-to-day market value. In addition to cropland soils, feasibility of trading C sequestered in forest, rangeland, and urban soils (turfs, lawns, golf courses) must also be studied.
- Among different climatic factors, rainfall and temperature are the most dominating ones influencing nutrient leaching from soil. It is high in humid climate but, in arid and semiarid regions, K leaching is enhanced by the presence of gypsum and calcite in the soil. The application of N fertilizers with organic manure increased N leaching even by 200–300% over control (Sharma and Chetani, 2017).
- Nano-technology is showing promise and may help improve the nutrient efficiency of not only phosphate fertilizer but also nitrogen and potassium, besides micronutrients like zinc and boron (Mura et al., 2013). Nano-fertilizers release the nutrients in a controlled manner in response to reaction to different signals such as heat, moisture, etc. For example, Titanium dioxide (TiO2) increased the light absorption and chlorophyll content in the plant, while zinc oxide nanoparticles had a twin role of being an essential nutrient and a cofactor for nutrient-mobilizing enzymes. With these the tomato plants were better able to absorb light and minerals

producing nearly 82% (by weight) more fruit than untreated plants, and the fruit had higher antioxidant (lycopene) content.

- Following eco-friendly and bio-rational practices including IPM, INM, ISPM etc. for crop specific important pests of commercial crop cultivation. Crop specific integrated production and management technologies are available and information technology today can enhance connectiveness and make data readily available to workers even in remote areas of the world.

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Appendix

Soil microorganism in sample analysis of selected VDCs in Dang, Gulmi and Mustang districts

SN	Districts	Location	Result (cfu/g)		
			Trichoderma	Azotobacter	Actinomycetes
1	Mustang	Marpha	Nil	$4 X 10^4$	$2 X 10^4$
2	Mustang	Marpha	Nil	Nil	Nil
3	Mustang	Marpha	Nil	$2 X 10^4$	Nil
4	Mustang	Pangling	Nil	$5 X 10^4$	$2 X 10^4$
5	Mustang	Pangling	Nil	$2 X 10^4$	Nil
6	Mustang	Pangling	Nil	$7 X 10^4$	Nil
7	Mustang	Chiwang	Nil	$12 X 10^4$	Nil
8	Mustang	Chiwang	Nil	$4 X 10^4$	Nil
9	Mustang	Chiwang	Nil	$13 X 10^4$	Nil
10	Mustang	Chiwang	Nil	$6 X 10^4$	Nil
11	Gulmi	Chhatrakot	Nil	$6 X 10^4$	$4 X 10^4$
12	Gulmi	Dhurkot	Nil	$10 X 10^4$	$5 X 10^4$
13	Gulmi	Chhatrakot	Nil	$8 X 10^4$	$3 X 10^4$
14	Gulmi	Resunga	Nil	$16 X 10^4$	$10 X 10^4$
15	Gulmi	Chhatrakot	Nil	$4 X 10^4$	$9 X 10^4$
16	Gulmi	Resunga	Nil	Nil	$4 X 10^4$
17	Gulmi	Dhurkot	Nil	$8/ X 10^4$	$3 X 10^4$
18	Gulmi	Dhurkot	Nil	$13 X 10^4$	$9 X 10^4$
19	Gulmi	Resunga	Nil	$6 X 10^4$	$4 X 10^4$
20	Gulmi	Resunga	Nil	$9 X 10^4$	$5 X 10^4$
21	Dang	Saunepani	Nil	$2 X 10^4$	$9 X 10^4$
22	Dang	Saunepani	Nil	$1 X 10^4$	$3 X 10^4$
23	Dang	Saunepani	Nil	$4 X 10^4$	$4 X 10^4$
24	Dang	Baghmare	$1 X 10^4$	$5 X 10^4$	Nil
25	Dang	Baghmare	Nil	$4 X 10^4$	$2 X 10^4$
26	Dang	Baghmare	$3 X 10^4$	$6 X 10^4$	$4 X 10^4$
27	Dang	Shantinagar	Nil	Nil	Nil
28	Dang	Shantinagar	Nil	$6 X 10^4$	$3 X 10^4$
29	Dang	Shantinagar	$2 X 10^4$	$3 X 10^4$	$9 X 10^4$
30	Dang	Shantinagar	$2 X 10^4$	$6 X 10^4$	$4 X 10^4$